ROADS and STREETS

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Are We About to Break All Records of Productivity?

The output per worker in the manufacturing field was 35 per cent greater in 1925 than in 1914, and the buying power of his weekly wage was 33 per cent greater, according to the National Industrial Conference Board. "These figures," says the Board, "hold the chief explanation of the unparalleled growth of our national wealth and income."

It is a fine achievement to have averaged a 3 per cent annual increase in productivity per manufacturing worker for a period of 11 years, but it is not unparalleled. In an article on price levels, published in "Engineering and Contracting," April 7, 1920, and reprinted in Gillette's Handbook of Construction Cost, the productive efficiency per manufacturing worker was given from 1869 to 1914. Reference to those statistics shows that a 3 per cent annual gain in productivity was almost attained during the decade ending 1899. Then followed 15 years of stagnation in the manufacturing field, so far as annual productivity per worker was concerned, probably due largely to the shortening of the working hours and to some extent to the increase in union restrictions on output.

Since 1914 we have renewed the rapid strides that we had been taking up to 1899, but we are not yet justified in calling our progress unprecedented.

Our general per capita productivity increased 22 per cent during the decade of 1879 to 1889, 15 per cent during the decade of 1889 to 1899, and 11 per cent during the decade of 1899 to 1909. This includes farming, mining and manufacturing. It showed a progressive decline in the rate of productivity increase, until it culminated in almost complete cessation of progress during the period of 1909 to 1914. The world war galvanized us into activity again, and for 13 years our progress has been splendid. Yet it has not broken any records, despite the general belief to the contrary. When we can show a decade of, say, 40 per cent increase in per capita productivity, then we may be justified in talking about the breaking of records. That we seem to be on the verge of making such a record is beyond doubt. If we can escape business reactions, if more farmers will leave the farms and more coal miners will leave the mines, if labor unions will cease their restrictions on output, if workers will postpone the five-day week for another decade —then there is scarcely a doubt that we shall register a 40 per cent increase in per capita output, and a 40 per cent increase in "real wages" in 1935 as compared with 1925. Converted into dollars, this means that the average employe who earned $1800 in 1925 will earn $2500 in 1935; and that the buying power of his wage, his "real wage" will be proportionately increased.

There will be no miracle involved in such progress. We have already proved that it can be attained, for it has been exceeded by entire lines of industry, and has been greatly exceeded by individual managers in every line of industry.

While socialists have been talking about eliminating the profits of capitalists, those very capitalists in America have been increasing the "real wages" of their employes by a far greater percentage every decade than the percentage that profits represent. Furthermore, the employes have become capitalists themselves, and at such a rate that it will not be long before they will own most of the stock and bonds of our corporations.

H. P. Gillette

The Exodus from the Farms

It has been estimated that since 1920 about four million people have left the farms, which is at the annual rate of about 2 per cent of the farm population, and that the year 1926 was no exception to this rate of exodus.

There are now about 27 million people on the farms, or about 23 per cent of our population.

Lloyd S. Tenny, Chief of the Bureau of Agricultural Economics, is quoted as saying: "Agriculture cannot increase its labor-unit productivity rapidly enough to offset a loss of 600,000 farm people a year for an indefinite period of years. If this depopulation continues the time will come when farm prices will rise to a relatively high level and consumers will begin to fear a food shortage."

Yet in the same interview Mr. Tenny states that agriculture has kept pace with manufacturing in the increase in productivity per worker, and a chart is given showing that the average farm worker's output increased 26 per cent during the decade of 1910 to 1920. This does not jibe with his statement that the country will suffer if there continues to be an annual decrease of 600,000 in the farm population, for 600,000 is only 2.2 per cent of the 27,000,000. On the contrary, if his estimate of increased productivity per farm worker is correct, it is evident that there need not be the slightest worry over the exodus from the farms. Indeed that exodus is clearly the only solution of overproduction of farm products.

Mr. Tenny seems disturbed over the possibility that the manufacturing industries will be injured by a continued influx of workers from the farms, for he says:

"Heretofore, in recent years, whenever manufacturers found one outlet choked they could find another by taking up some new sort of product. That can't go on forever."

Why not? It has gone on for a century and a half in America, and there isn't the slightest indication that it

cannot go on indefinitely. The farmer's products are mainly food, and for food there is a limited demand, namely about four pounds daily per human stomach. But for many other products the demand is almost as elastic as the income. Take residences and furniture, for example. From the log cabins of our pioneer forefathers to our own good homes is a far flight in luxury, but it is still only the beginning of a much farther flight. From their trails and mud roads to our improved highways is also a far flight, yet three-fourths of our enormous mileage of roads is sadly in need of improvement. By the side of our rich citizens the average citizen is still poor, yet the difference in their possessions is one that need not continue to exist, nor need the difference be wiped out by bringing the rich down to the level of the poor. On the contrary, it will be wiped out by making the poor rich; and that can be done only by greater and still greater productivity.

Narrow indeed is the vision that leads to the conclusion that increments in manufacturing productivity "can't go on forever."

Automobiles and Railroads

Editorial in New York Times

That motor vehicles have been steadily diverting traffic from the railroads since 1920 is common knowledge. From the last report of the Interstate Commerce Commission it appears that the diversion has proceeded at such a pace that railway passenger earnings declined $346,000,000 in 1926.

Our 20,000,000 motor vehicles of all types represent an investment of $18,000,000,000 — three times more than the sum invested in railroad motive power and equipment. Of our 3,000,000 miles of highway 500,000 are hard-surfaced, and these 500,000 have cost about $8,000,000,000. This gives us a total of $26,000,000,000 for motor vehicles and hard roads—about $3,000,000,000 more than the investment in railroads. Since we are spending $1,000,000,000 a year annually in highway construction—more than the railroads are plowing back in improvements and extensions of trackage—we may expect the motor vehicle to cut still more deeply into railroad revenues.

Prof. W. J. Cunningham, who occupies the chair of transportation in the Harvard Graduate School of Business Administration, warns us in "The Railway Age" not to leap at the conclusion that these startling figures doom the railroad to fill a minor place in our transportation system. Although our passenger motor vehicles can move half the population of the country at one time, although their capacity is thirty times greater than that of our railroad passenger cars, although the estimated passenger-miles of motor vehicles, excluding those of our cities, is three times as great as the actual total passenger-miles of the railroads, and although the motor truck hauls freight for distances under fifty miles more efficiently and cheaply than the railroad, the locomotive and the steel rail remain invincible in their field. But what is this field? It is not what it was. It must be resurveyed.

It so happens that the freight and passenger traffic diverted to the highway is least remunerative to the railroad. Hence we find railroads already cultivating the long-haul shipper rather than all shippers indiscriminately. Professor Cunningham regards this as a boon. If the astounding growth of freight traffic in the last two years is maintained, the dwindling surplus of cars may be changed into a shortage. The conclusion is reached that "further losses of "short-haul traffic might be a blessing "in disguise." Instead of ordering additional freight cars, the remedy is obviously to buy motor trucks and to use them as feeders in a nationwide door-to-door delivery system, with the result that desirable economies will be effected in railway terminal administration, in freight-car utilization, and in reducing the congestion on crowded city streets.

Because it affects both passenger and freight traffic, this curious twist given to transportation economics by the advent of the automobile demands a voluntary limitation in the use of both motor vehicles and railway equipment, and hence a "statesmanlike attitude in which "purely selfish corporate and individual "interests shall be subordinated to the "public good."

When You Estimate, Don't Guess

Editorial in April 25 Public Construction News.

The street and highway contracting field as a whole is now out looking for business. There is much construction in prospect for the spring and summer months, and the next few weeks should see the beginning of a great deal of activity. But it must be remembered that activity in itself counts for nothing. If a contractor loses money on every square yard of pavement he lays, the more business he does the more money he will owe himself by the time cold weather calls a halt to his activities.

The only way to know whether you are making money is to figure your bids on a scientific basis—that is, in the light of past records, and with absolutely no guesswork. The day is long past when a contractor could safely submit a bid based on an estimate that was compiled by totaling the costs of the materials to be used, together with the salaries to be paid during a guessed-in period of time, and lumping on to this a sum which the bidder hopes would care for all possible accidents, wet weather and other mishaps.

Such methods were well enough in a day when business in general was regarded as a sort of gamble wherein every player was expected to hold a couple of cards up his sleeve. They are as far behind modern methods, however, as the pony express is behind the air mail. No highway contractor would dream of doing his grading with an ox team. Why should he persist in using accounting methods that passed when the ox-team went out of fashion?

Putting accurate figures into an estimate is admittedly hard work. It calls for great mental effort, and all of us admittedly like no more of that than is necessary. Yet safety lies only in taking precautions. And precautions always require work and attention to detail.

The Illinois Association of Highway and Municipal Contractors has been working for some time upon a standard form to be used in preparing road and street estimates. Much difficulty has been experienced in drawing up one which would be universally applicable but the work is progressing and prospects of ultimate success are bright.

In the meantime, whenever you feel a vague, half-defined impulse to say: "Oh, I guess that item'll come to about —er—uh—let's see, now——." Choke it down, by all means. Guesses should have no part in the bid. Past records or calculations arrived at by figuring are the only reliable material with which to build an estimate.

Your records may not apply exactly in this case, and your calculations may prove wrong, but even so, they are a hundred per cent better than guesses.

Causes of Spalling

To the Editor: In your April issue of Roads and Streets, on page 156, you printed a letter under the heading "Aggregates Cause Spalling." The writer believes that this is very probably an occurrence of frost action in connection with chert aggregate. If you will refer to the April 16th issue of Rock Products you will find illustrations of this action and the August, 1924, issue of the Engineering News Record carries an article describing this action in detail.

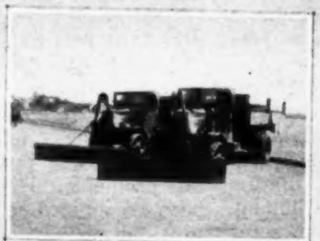
Alternations of freezing and thawing of the aggregate in question should give an accurate idea of stability. Five alternations will generally give very positive results with unstable chert. The aggregate should be soaked in water for 24 hours and then placed in a small metal container with a small quantity of water to insure saturation. Packing of the metal container in a salt brine solution, containing cracked ice, over night, will give positive freezing action.

F. V. REGAL,

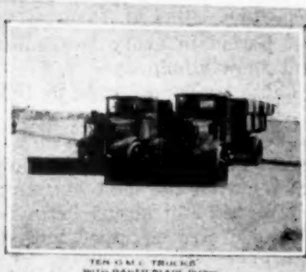
Engineer of Materials, Missouri State Department, Jefferson City, Mo.

SIX BARBER GREENE SNOW LOADERS

TWO NELSON SNOW LOADERS

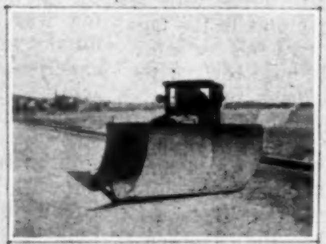


TWENTY MACK TRUCKS WITH CHAMPION BLADE PLOWS SHOWING BALLAST BOXES



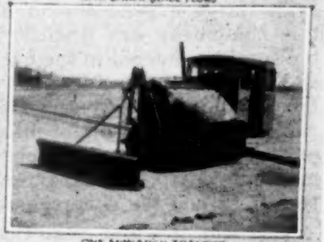
TEN G. M. C. TRUCKS WITH BAKER BLADE PLOWS

TWO BEST & HOLT TRACTORS WITH SARGENT PLOWS

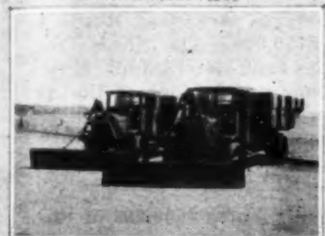


THREE MEAD-MORRISON TRACTORS WITH WALSH "V" PLOWS

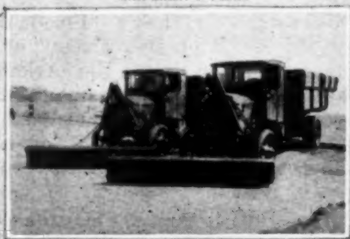
ONE AMERICAN LAFRANCE TRUCK WITH CHAMPION BLADE PLOW



ONE MONARCH TRACTOR WITH CHAMPION BLADE PLOW



TWENTY WHITE TRUCKS WITH CHAMPION BLADE PLOWS



TEN AMERICAN LAFRANCE TRUCKS WITH CHAMPION BLADE PLOWS

ONE MACK WRECKER

ONE REO EMERGENCY TRUCK AND TWO FORDSON

NINE PIERCE ARROW TRUCKS

Snow Removal at Boston

Equipment and Methods Used During Winter of 1926-1927 by Public Works Department

By THOMAS J. WATSON

FOUR OVERLAND WHIPPET AND DODGE AUTOMOBILES

During the past winter the Public Works Department of the city of Boston, Mass., placed in service a large amount of new snow removal equipment. This equipment consisted of 20 Mack, 20 White, 11 American LaFrance and 10 G. M. C. trucks equipped with Champion and Baker blade plows. Nine Pierce-Arrow trucks were used without plows to remove snow to the dumps, while the other trucks were plowing. Beside these trucks there were three Mead-Morrison tractors equipped with Walsh "V" plows, two Holt and Best tractors with Sargent plows, one monarch tractor with Champion blade plow, six Barber-Greene and two Nelson snow loaders, two Fordsons, also a modern Mack wrecker, which is really a repair shop on wheels, and an emergency Reo truck, which was used for conveying the men.

The greater part of this equipment was used in the downtown section, comprising the shopping, railroad and market districts. This section was divided into 15 plowing districts, consisting of 44 plowing routes. Each district was in charge of an inspector, whose duty it was to see that all streets in the district he was assigned to, were properly plowed.

Each chauffeur, as he left the garage, was given a printed route card with the names of the streets that he was to plow, he to stay on these same streets for the duration of the storm. In order that he might remain on his route continually, gasoline and oil was supplied to his truck by a 500 gal. tank truck which patrolled the different districts during the storm.

Supervisor of Snow Removal George H. Foss and his assistant, Thomas J. Watson, carried key cards on their tour of duty. If they found a street that was not plowed to their satisfaction, they were able to tell at once, by consulting the key card, which chauffeur was to plow it and which inspector was in charge of the district. In this way a check was kept on all trucks plowing.

When the storm ceased and the streets were plowed to the satisfaction of the supervisor, the inspector then organized a snow removal gang by hiring about 20 emergency men to load the same trucks which he used in plowing his district, to remove the snow to the dumps.

Beside the equipment above mentioned, 30 trucks with blade plows were hired from contractors to open up the main trunk lines in the outlying sections, after which they plowed the side streets.

The majority of the storms the past season came at night after 10 o'clock when the men had retired, or on Sunday when the men were not working, which necessitated sending for them. But working under this handicap, as most of the chauffeurs and plowman lived in outlying districts, every plowing route was covered inside of four hours after the assembling of plows and the ballasting of trucks had been started. In accomplishing this, the night operators of the Back Bay telephone exchange and the police were of great assistance in notifying the men.

And the manner in which the men responded to our call is most praiseworthy; also their loyalty in working during the storms should not go unmentioned. During one storm the men

stayed on their routes plowing from 3 p. m. Sunday to 2 p. m. Monday. The inspectors allowed them a 15-minute rest period in every two hours to prevent snow blindness.

These trucks are used by the sanitary service during the day, when they are not on snow work. Every night 15 trucks are equipped with plows, which are removed the next morning. Saturday nights and nights before a holiday 30 trucks are equipped with plows for emergency.

The large expenditure of money for this equipment was greatly repaid by the service rendered to the business men and traveling public, as was verified by the thousands of letters received from people in every walk of life, such as pastors of churches, automobile owners, marketmen, truck and team owners' associations and the general public.

This was the first year that the entire laboring force was not compelled to be sent into the market district to pick ice on Sundays following a heavy storm, which was, of course, a great saving of money. On account of plowing, very little picking had to be done this season, consequently the streets were in much better condition this spring, since there was very little rutting.

Convention of Canadian Good Roads Association.—The 14th annual convention of the Canadian Good Roads Association will be held at Niagara Falls, Ont., on Sep. 27, 27 and 29.


Letting the Rodmen and Chainmen over an 85 ft. Drop During the Progress of the Survey This Is Indeed Surveying under Difficulties.

Locating Highway Under Difficulties

How Surveys for Mountain Road in Bad Lands of North Dakota Were Made

Many a yarn has been spun on the adventures of location parties, and many a tale has been told of how a route has been staked in spite of difficulties of terrain that were encountered. North Dakota, ordinarily considered a prairie state, is the site of such a tale. In the western part of the state, where the plains are broken by the buttes in the region known as the Bad Lands along the Little Missouri River, the location of the proposed crossing of Federal Highway No. 85 with that river presented real difficulties.

According to the North Dakota Highway Bulletin, the Bad Lands made a descent at this point of 556 ft. in slightly over a mile, and the location of the highway thus presented interesting problems. The result is what has been recognized as a true bit of mountain highway.

Descending from the north wall of the canyon the survey clings to the face of a very precipitous cutbank for a distance of about a half mile toward the southeast, then loops back toward the north and northwest until, after traveling somewhat over one-quarter mile the centers are only 147 ft. apart horizontally but over 75 ft. apart vertically. The center line then turns to the southwest, then loops to the southeast around the west end of the ridge, then loops once more to the southwest, then curves between some smaller intervening buttes to a bridge site a few hundred feet down river from the present location of Challoner's Ferry.

The ascent of the south wall necessitated but one loop to reach the mouth of a draw and thence to its rim.

In making the survey, all distances along the center line were made on the horizontal. In every case the tape was held horizontally and when necessary a plumb bob at the end gave the lower point at the ground. Where the ground proved too steep for accurate chaining with the full length of the tape, fractional lengths were used. In a few cases even this could not be resorted to because of the steepness of the ground, and in these cases the distance along the slope was measured, the angle of slope was measured, and the true horizontal distance between the two points then computed. In order that assurance may be had as to the accuracy of the computations on the curves in this difficult location, all curves were run and closed in the field. This part of the work totaled about 47 per cent of the line.

The cross sectioning also presented difficulties. Although the normal section is 66 ft. wide, over 60 per cent of the sections on this survey ranged from 100 to 325 ft. in width, and some had a difference in elevation from end to end of over 210 ft.

For a total of about one-quarter mile in various places the rodmen and tapemen were slung in ropes to prevent their "leaving the party" as a tumble came to be called. The weather, too, added to the troubles of the party. On the north side almost daily rain or fog was encountered, while sleet and flurries of hard driven pellet snow were experienced almost every day on the south. The rain caused the buttes to become very slippery and footing on the steep slopes proved very difficult. In spite of it all, the party carried on and the work proceeded to an early and satisfactory conclusion. Engineer L. H. Belk was Chief of Party.

Flood Damages Arkansas Roads to Extent of $750,000.—The floods from the Arkansas and Mississippi Rivers damaged roads and bridges of the Arkansas state highway system to the extent of about $750,000, according to press reports.

Texas County Votes $600,000 of Road Bonds.—LaSalle County, Texas, has just voted, 455 to 7, to issue $600,000 in road bonds to complete a gap in the Meridian Highway and to finance an east and west road through the county.

Batch Boxes Handle Material on Chicago Street

How Rural Highway Methods Are Solving Haulage Problems for the Contractor Laying Concrete Base for Widening of Lake Shore Drive in That City

A sand and cinder subgrade on the new right of way for the widening of Lake Shore Drive in Chicago presented special problems that were met by the paving contractor in an interesting way. This new street, of sheet asphalt on a reinforced concrete base, is now being paved by methods that have seldom been seen within the city limits, or for that matter within the limits of hardly any other city, with the exception of Detroit. A central proportioning plant supplies the batches to the mixer by means of batch boxes hauled on cars along a narrow guage railway, thus eliminating cutting up of the subgrade and consequent regrading that would be required should the usual batch trucks be used.

The Subgrade.—West of the centerline the subgrade was found to be an old bridle path of slag and cinders, well compacted from years of service, and extending for the entire distance from the Drake hotel to the south boundary of Lincoln Park. On the east half the soil was lake sand with a thin topping of black dirt and sod. In preparing the subgrade this black dirt was first removed by steam shovel and hauled away for other use. Sand removed to bring the subgrade to grade was also removed in the same manner. The top layer of cinders from the bridle path was then removed by the steam shovel and spread on the sand half of the subgrade, and the entire subgrade was then rolled. This work called for moving about 15,000 cu. yd. of dirt. Trees first had to be removed. Water mains, sewers, street lighting conduits, and other underground work was put in, and a combined concrete curb and gutter was laid.

Aggregate Supply.—Crushed limestone and screenings used as aggregates in the concrete were delivered to the subgrade in motor trucks from the quarry of the Chicago Union Lime Co., at 19th and Lincoln Sts., some distance away. These trucks drove onto the subgrade at the intersection of Bank St., about 200 ft. north of the center of the job, which has a length of about 4,000 ft. Here the screenings were dumped on one pile and the course aggregate on another, opposite the bins. A Byers model 10 gasoline crawler crane, equipped with a ¾-yd. clamshell bucket, standing between these stock piles, was used to move the aggregates from the stock piles into the elevated batcher bins.

The elevated steel Butler bin, holding about 40 cu. yd. of stone and 20 cu. yd. of screenings, was equipped with four batchers of the same make, two batching the course aggregate and two batching the screenings.

Cement Handling.—Universal cement, in cloth sacks, was delivered to the job by trailer from the mill at Buffington. These trailers were spotted on the subgrade about 300 ft. from the batcher plant and alongside the track, and remained in place as loading platforms until the entire load had been placed in the batch boxes, as required by the mixer.

Proportioning.—Four-bag batches of 1:3:5 concrete were made up at this plant in batch boxes carried on flat cars. These cars, made by Easton, each held two Lakewood batch boxes each holding all materials for a batch. These cars were made up into trains of three. Four trains were used on the job. They were hauled by means of two Plymouth gas locomotives, providing for two trains to be in transit while the other two could be loading; one with aggregates and the other with cement. A constant flow of materials was thus pro-

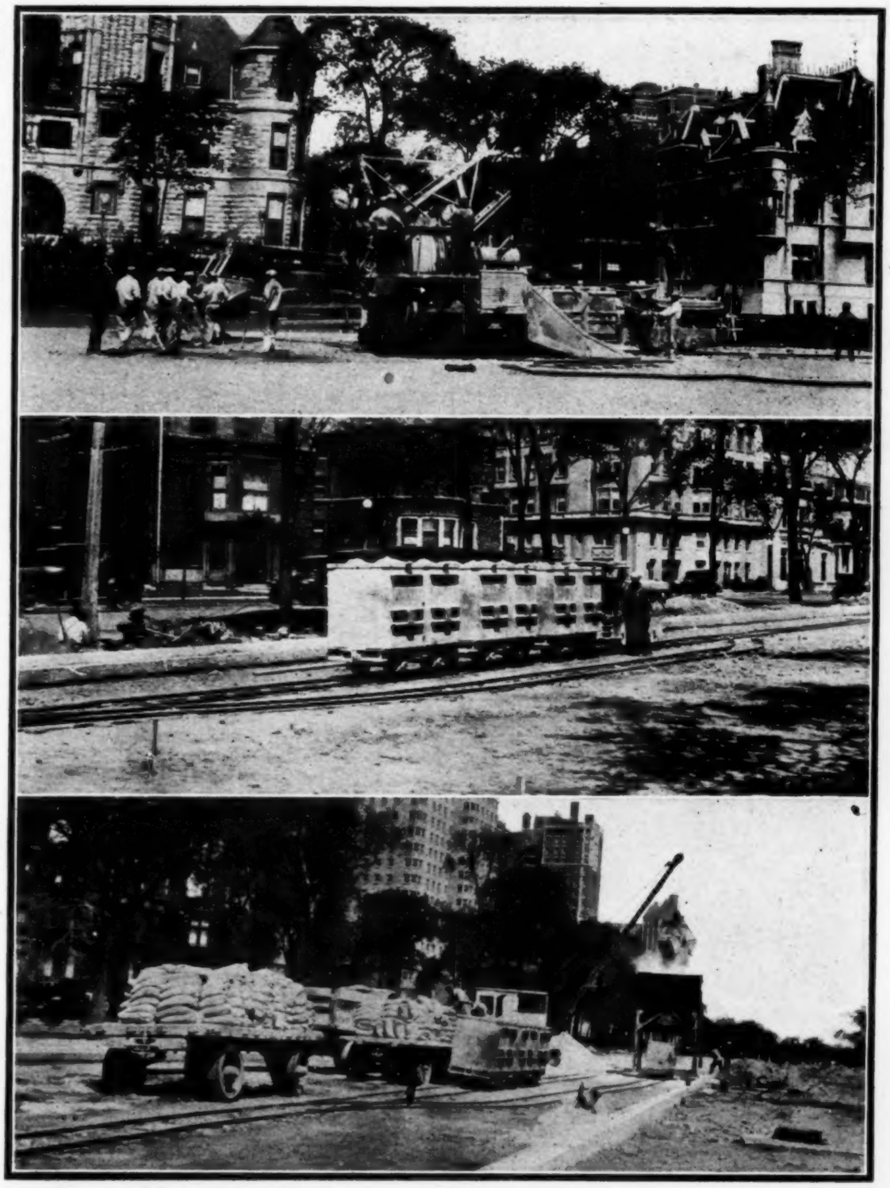


Fig. 1.—Top: The Mixer Crew at Work, With Batch Box Being Swung from Car to Skip, a Batch Being Mixed, and Another Just Dumped on Subgrade. Peter Westberg, Superintendent, on the Far Left. Center: Three Hundred Feet from the Mixer a Loaded Train Waits at the Passing Track With Six More Batches. Bottom: Two Thousand Feet from the Mixer, Aggregates Being Loaded Into the Bin by Crane, Train of Batch Boxes Receiving Aggregates, and the Remaining Train of the Four Is Taking on Cement from Trailers Before Being Taken to the Mixer.

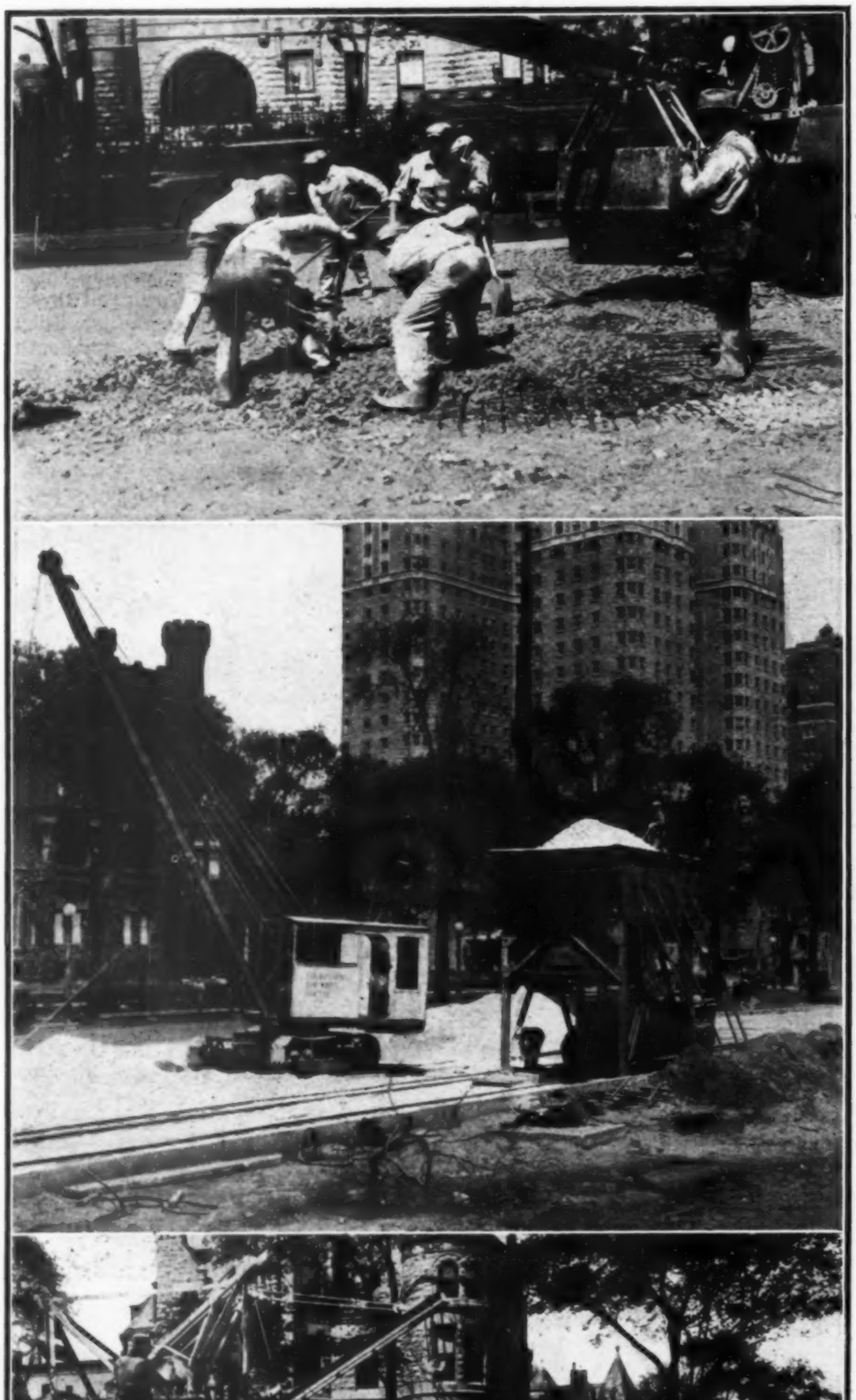


Fig. 2.—Top: The Shovel Gang Spreading a Batch of Concrete on Top of the Steel. Note the Fairly Dry Consistency of this Concrete. Center: Closeup View of Aggregate Plant With Stockpiles, Crane, Bins, Batchers, and Boxes Being Loaded. Bottom: The Three Batch Box Men Dumping a Load Into the Skip. The Two Hookers Ride the Box While the Boom Man Shoves Between Them

vided for by two locomotives with a maximum haul of about 2,000 ft. Course aggregate was graded from 2 in. down to ½ in., while the screenings were graded from ½ in. down, with the dust removed.

The Track.—The track was so arranged that a single line and two sidings permitted a free flow of traffic without confusion or loss of time. A single line from the mixer led to a short passing track 300 ft. from the mixer, and a single line again carried the trains to the proportioning plant. The passing track near the mixer was moved at the end of every day's run. Just before coming to the cement trailers another switch was installed, affording a siding about 10 ft. from the main line and parallel to it, and running underneath the aggregate bin. On the far side of the batchers this track again curved to meet the main line track, joining it with another switch.

Thus an empty string of batch boxes could be pulled by the locomotive from the mixer, passing a loaded one at the passing track, and directly from there to a position under the batchers. Here it would be uncoupled and left to be loaded with aggregates. The locomotive would then hitch on to a loaded string at this point, pushing it on to the junction and onto the main line. Then going into reverse, the locomotive would pull this string down the main line to the cement trailers, uncouple and leave it there for the cement, hook up to the other string waiting there with a load of cement and aggregates, and push the load of completed batches back to the mixer, passing the empty string at the passing track that had just left the mixer. Thus the cycle of batch supply would be repeated throughout the day's run. The track units were also supplied by Easton.

Material Crew.—To supply this flow of materials to the mixer, besides the two engineers driving the locomotives, a crew of 7 men was needed. The table of organization was as follows:

Crane man	1 at $1.50
Lever men (batcher)	2 at .90
Laborer	1 at .90
Cement hands	3 at .90

The locomotive drivers, of course, were engineers at the current scale of $1.50 an hour. The laborer shown in the tabulation was posted on the top of the bin to see that the screenings flowed down into the batchers without arching and jambing in the hopper. The lever men, who operated the batchers, also aided the locomotive drivers in hooking up at the batchers.

The Paver.—The actual paving operation was accomplished by means of a Multi-Foote 27E paver, equipped with a swinging boom to handle the batch boxes. Batch boxes were swung from the cars and their contents dumped into the skip. Mixed concrete was dumped and spread on the subgrade in the usual manner. The mixing time was about ¾ min. to 1 min. This 9½ in. base, 43 ft. wide between gutters, was laid in the following manner at the rate of 300 lin. ft. an 8 hr. day. First the layer of concrete beneath the steel was laid over the area covered by about two sheets of reinforcing. Next the sheets of 50-lb. wire mesh were laid in place and forced into this surface of soft concrete. Next, on the east half only, ½ in. bars spaced 2 ft. on centers, were laid lengthwise the pavement, lapped one foot, on top of the mesh. Then the remaining 3 in. of concrete was laid and brought to the desired surface with the broom. The concrete was mixed with just enough water to give sufficient workability to thoroughly embed the steel.

Mixer Gang.—The gang at the mixer is organized as follows:

Engineer	1 at	$1.50
Helper	1 at	1.50
Loaders	3 at	.90
Shovel men	5 at	1.69½
Finishers	2 at	1.60
Laborer, reinforcing	1 at	.90

The engineer and helper operate the mixer, one of the loaders helps swing the batch box boom by means of a rope, two of the loaders hook the batch boxes off the cars, dump them, and ride them to complete the dumping operation, and then replace the batch boxes on the cars, while the shovel men spread the concrete, the broom men finish it with brooms and a tamper, while the laborer easily handles the sheets of steel, brining them up as needed, moves the water hose, and otherwise makes himself useful around the mixer. The superintendent generally stays at the mixer end, visiting the proportioning end of the job, but occasionally should the batches show that something had gone wrong. With this organization and equipment the mixer averages about 30 batches per 8-hr. shift. The job works but one shift, yet the work promises to be completed a week before the date called for in spite of an unusual period of bad weather that was experienced during a great part of the job.

Asphalt Work.—The asphalt work required about 12 days to complete. The contract called for 1½ in. of binder and 2 in. of sheet asphalt top. The asphalt was hauled in 9-ton covered trucks from the plant at Cicero Ave. and Roosevelt Rd., 8 or 9 miles away, and was spread in the usual manner, and rolled with 2 8-ton tandem gasoline rollers and 1 10-ton, 3-wheel roller. This haul required about 40 min. on the average. The work progressed at the rate of 2,000 sq. yd. a day.

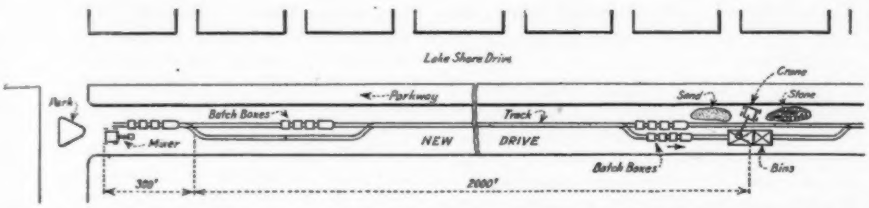


Fig. 3.—Sketch of Layout of the Work, Showing Mixer at the Left, Then the Passing Track With Waiting Train, and at the Right the Proportioning Plant With Its Equipment and the Handy Track Layout

The work was done under contract for the Lincoln Park Commissioners by the Commonwealth Improvement Co., Chicago, of which Walter Leninger is engineer. The work in the field was under the supervision of Peter Westberg, concrete superintendent, and was done by a trained force that had been employed by the same firm for a number of years.

How New York City Maintains Its Motor Vehicles

The city of New York now maintains over 4,000 motor vehicles. For the handling of the repairs of this fleet the city has erected a repair shop at Avenue C and East 16th St. This is a 10-story structure with eleven acres of working floor space, approximately 480,000 sq. ft. The type of building is that of reinforced concrete or factory construction, and it cost for foundation, superstructure and additional equipment about $4,000,000. In this structure there are seven elevators, large enough to carry, with few exceptions, any piece of motor equipment in the city service. Here all the work required completely to overhaul and paint a piece of motor equipment can be done economically and efficiently. Formerly a complete overhaul and paint job would have to be sent to five different shops, located in three boroughs, before it could be finished.

The shop is equipped with a direct current of 240 volt service for light and power on all floors; also with an alternating current, three-wire, 240-volt service for power only on the first, fourth and eighth floors. Steam—high and low pressure—on all floors for power, heating and ventilating are furnished the plant by the oil fuel system from the Willard Parker Hospital plant. There is also a compressed air service at 90 lbs. for power only.

Each floor has been carefully planned for handling the various stages of complete motor overhauling under thoroughly modern scientific plant operation. In addition it is contemplated to have special field forces of inspectors and a force of field mechanics. The ultimate aim of the plant is to make a complete overhaul of the city motor fleet once each year. The Central Motor Repair Shop is operated as a bureau of the Department of Plant and Structures.

New Roads and Horseshoes in Czechoslovakia

In No. 24 of the Public Service Technical Reports, 1926, of the Public Works Department of Czechoslovakia, in the section devoted to the subject of Roads, M. J. Svoboda C. E. draws attention to the fact that work will shortly be commenced on the improvement of the surface of the main public highways. As horses are still very largely used in Czechoslovakia for the conveyance of both persons and goods, it will be essential for the authorities to pay attention to the subject of an appropriate method of shoeing horses, in order that the special and expensive surfaces of the roads (asphalt, concrete or tar surface) shall not be unduly damaged by rough shoes. In other countries flat shoes without sharp toe and heel calks (except in time of frost, when the roads are slippery) are used whereas in Czechoslovakia it is the screwed-on heel calks which do such havoc with smooth road surfaces. This question is also treated of, from a veterinary and farmer's point of view, in a volume from the pen of Prof. Hanslian, head of the Shoeing Section at the Veterinary College in Brno, entitled "Proposals for a New Method of Shoeing Army Horses." In this book the author recommends that horses, which have light loads to draw should be shod with shoes without calks; and that those which have to draw heavy loads should have shoes without toe calks, that is, with only the heel calks. It would be advisable to test these proposals, and if they stand the test successfully, to introduce a new method of shoeing horses.

New Jersey to Spend $18,000,000.—The State Highway Commission of New Jersey contemplates spending ten million dollars this year on paving and another eight million to build approaches to the Holland Vehicular Tunnel under the Hudson River, according to a recent announcement. Almost 100 miles of paving will be laid, leaving less than 80 of the 728 miles in the original highway program. More than $1,500,000 will be expended to widen the approaches of the Camden Bridge, where serious congestion of traffic has developed.

What Is a Fair Profit in Highway Construction

Items That Should Be Considered in Estimating Discussed in Paper Presented Before American Road Builders' Association

By A. E. HORST,

Secretary-Treasurer, Henry W. Horst Co., Rock Island, Ill.

The construction business is one of the most important factors in the development of civilization, and constructors are entitled to a just and reasonable profit for their work. If reasonable profits are not realized, something is wrong with the individual or with the group.

Definition of Profit.—Among contractors the word "profit" has probably as many meanings as there are groups of contractors, therefore, in order to discuss this subject intelligently it is necessary that we contractors at least agree on a definition of profit, so that when profit is mentioned we may all be thinking of the same thing. One group of contractors in discussing profit, will have in mind gross profit and may include such items as insurance, surety bond premiums, overhead of every description, etc., while another group may have in mind that profit added to their bid should include all of the above items plus even depreciation or plant rental on equipment, while still another group may have in mind only the net or real profit after all charges, contingencies, etc., are properly disposed of in their estimate. Personally, I like to see an estimate prepared on a job include every item of expense that it is possible to include intelligently, and then add amounts for contingency and net profit. Net profit is the excess of income over expenditure.

Preparing an Estimate.—In order to lay a proper background for the purpose of this paper, let us assume that a contractor is preparing an estimate on proposed highway work in which estimate we have such general headings as Excavation, Concrete Work, General Expenses, Plant Expense, Overhead.

Under the heading of Excavation we tabulate the labor (and material, if any be required) for clearing, general excavation, borrow, excavation for structures, shoulders and ditches.

Under the heading of Concrete it is not very difficult to tabulate the items of labor and material, such as bridge and culvert work, mixing and placing concrete slab, subgrading, hauling materials, concrete gutters, precast culverts, drop inlets, rip rap, unloading materials, water-line, pumping, etc.

The General Expense items are sometimes a little more difficult to analyze but we like to segregate them as follows: liability insurance and bond premiums, temporary buildings, field office expense, superintendence, bonuses, securing and transporting labor, engineering on the job, commissary and bunkhouse loss.

All of the items thus far under the various headings can pretty definitely and intelligently be estimated on work contemplated even though the contractor may have had only one year's experience.

Items Under Plant Expense.—To estimate intelligently, however, the items under the general head of Plant Expense requires a number of years' experience or else the contractor is likely not to include enough money for the items which follow:

General Plant Rental should cover rental of such equipment as mixers, trucks, portable buildings, rollers, finishing machines, tractors, pumps, etc.

Semi-Permanent Plant should cover all items of value of $100 or more which are charged directly to the job and for which a proper salvage value is given the job at completion of contract, such as all water pipe, road forms, etc., also all freight on such plant and general equipment.

Repairs to Permanent Plant should cover such charges of labor and material for all equipment used on the job other than temporary plant.

Temporary Plant should cover such items as wheelbarrows, shovels, power saws, miscellaneous tools, each worth less than $100 and freight on same.

Repairs to Temporary Plant should cover such expenses as are involved in repairing of temporary plant.

Fuel, Oil, Light and Power should cover fuel, oil, light and power used in excavation, rolling, grading, unloading materials, hauling materials, mixing and placing concrete and water supply.

Erection or Wrecking and Hauling of Plant cover all items in connection with permanent and temporary plant, such as building of bins, unloading plant, derricks, etc.

All of the above items come under the general head of Plant Expense and in the estimate a proper amount must be allowed for each item mentioned.

Standard Questionnaire and Financial Statement.—Let me digress further for a moment and say the "Standard Questionnaire and Financial Statement" that is being so universally brought into use, and for which our friend S. M. Williams deserves our greatest gratitude because of its inception by him and because of the consistent work he is doing to put it over, is going to help in stabilizing the industry so that we can secure a fair profit for our work.

These questionnaires show banking institutions what things, beside mere financial standing, constitutes responsibility in a contractor and makes him a safe risk in granting loans. The nature of the contracting business is such that mere honesty and satisfactory financial strength will not insure the payment of a loan. Skill and experience are equally important factors to be considered in determining what credit should be extended to a contractor.

They give banking institutions some adequate means of measuring responsibility of a contractor. That is, a form of financial statement containing other pertinent information, which will permit of intelligent judgment as to the size of a loan that may safely be made to an individual. Existing forms of financial statements developed for mercantile and commercial enterprises, when filled out for a construction company, do not give the vital information that a banker should have in forming his judgment. Some concerns who were over-extended could produce a respectable looking statement, while other concerns thoroughly entitled to considerable additional credit, might not appear so. This business has usually been considered an unattractive field by bankers, not merely because of its inherent hazards, but because they could never find out satisfactorily until a man steps up to the head of his industry, just how much money they could lend him with safety.

The questionnaire establishes a form of statement, which will necessitate maintaining an adequate system of accounting by a contractor. One of the most serious short-comings of the contracting business in general, is its failure to engage in proper accounting and a willingness to tolerate carelessness in accounting matters. To fill out this questionnaire and financial statement, a construction company must have an adequate system of accounting.

Rental Charges.—One hundred eighteen letters were mailed to various contractors stating that the writer was preparing a paper on the subject, "What Is a Fair Profit in Highway Construction?", and right here I want to express my appreciation to S. M. Williams for the assistance given me in writing these letters.

At this time I also want to express my appreciation to you contractors who graciously made replies to the letters sent out. Most of these replies brought out the fact that not enough rental was being charged by the contractor for the use of his equipment on the job. The most successful contractors in the highway business charge the job a rental for all equipment used on that

work and credit the rent thus obtained to an equipment earnings account. Against this equipment earnings account is then charged a fixed depreciation depending on the life of the equipment. This makes it much easier to secure the proper accounting on equipment, and each job carries its proper amount of rental. A specific instance may give you a more intelligent analysis of this.

A contractor purchases a mixer for $7,200. He believes, and decides this mixer will probably have a life of 36 months, but due to seasonal operation it will actually be operated only 8 months of each year, therefore, its actual earning power will total 24 months. The depreciation rate then is figured by dividing $7,200 by 36, or $200 per month, and this piece of equipment is depreciated that amount every month regardless of whether or not it is in use and this amount is charged to equipment earnings account.

The rental rate is figured in this manner. It is necessary, of course, to charge a higher rental rate than $200 per month because the mixer is not used every month in the year, there must be interest paid on the investment, there must be some repairs made on the equipment from time to time, there must be a charge for storage expense, and there must be a reserve set up in order that a new mixer may be bought when the old one is worn out. The job that uses the mixer the first eight months has a greater advantage in using a new piece of equipment than it would have if this equipment were two years old, and for this reason a higher rate of rental is charged the first eight months than the second, and a higher rate the second eight months than the third.

It is necessary then that in 24 months of operation the mixer must bring in its original price, $7,200, plus interest, 6 per cent for an average of 18 months—$648, plus a reserve, 10 per cent—$720, plus repairs and storage, 10 per cent—$720, making a sum total of $9,288. Therefore, the return on rental from this equipment must in three calendar years, or 24 months of actual operation, be $9,288, which is approximately 13/10 of the original price of $7,200. Because of the mixer being new, the job using it the first eight months is charged a rental rate of 6/10 of $7,200, or $4,320. The rental to be collected then is $540 a month. For the second eight months 5/10 of $7,200, or $3,600 is to be collected, which means $450 for each month from the eighth to the sixteenth month, and 2/10 of $7,200, or $1,440, which means $180 for each month from the sixteenth to the twenty-fourth month. If you will give this method serious consideration you will find that it has a sound basis and is not difficult to put into use.

Overhead.—We have now disposed of everything that enters into an intelligent estimate except "Overhead." Overhead covers many items that are not taken care of under the heads already discussed, such as officers' salaries, salaries of all main office help, estimating, interest on money invested, interest on notes payable, club and association dues, fire insurance, office supplies, automobile expense, gifts and donations, rent of office, stationery, light, telephone and telegrams, advertising, auditing, promotion expense, losses on jobs already closed out, taxes, expense of attending conventions, etc. After proper amounts have been set up in an estimate covering all of the above items of expense, then only two other main items are yet to be considered in making up the final bid. They are contingencies and the net profit that the contractor is entitled to.

On every job there is always the possibility of a contingency arising which has not been taken care of in the estimate. For this reason an intelligent amount should be set down in the way of contingencies. This then, leaves the matter of net profit yet to be added, which is the anticipated excess of income over expenditure.

Opinion as to Profit Varies.—With reference to profit, contractors in letters to the writer have expressed themselves as follows:

One contractor states, "We feel that before voicing an opinion as to a fair percentage of profit to be expected on highway construction, we would have to know whether the entire list of all costs entering into the work had been seriously considered, especially the many items of overhead cost."

The same contractor writes, "Our experience, based on our own particular job and from conversations with other contractors and a review of their cost systems has shown us potential profits, based on their costs, from 10 to 100 per cent, yet the fact that their actual profit would in no way correspond with the percentage added to their supposed costs, as profit, they cannot be induced to consider the actual cost involved in highway construction."

Another contractor says, "My opinion is, that if you are an experienced contractor for at least five years, put into your costs all of the items that you can possibly think of, add 50 cents a cubic yard for items which you will have, which you have not thought of, take out every form of insurance obtainable and then add something between 12 and 15 per cent, this should obtain a fair profit. I am frank to state I have not always bid in just this manner, but do think it necessary in order to get a fair profit."

Another contractor. "It has always been my practice never to figure less than 15 per cent net profit and from that up to 30 per cent, the figure being controlled by the natural law of supply and demand."

Another contractor. "I have only one thought which I might suggest. Every contractor includes in his costs such items as costs of materials, direct labor charges, insurance, bonds, etc. These items are definite and tangible. The one cost which I believe and I think is universally figured too low is the proper rental charge of equipment against each job.

"I often have occasion to rent out such equipment as steam shovels or other heavy machinery, and the price which the average contractor wants to pay me is just about one-half of what I charge against my own jobs, and I believe that failure to properly depreciate and write off equipment charges has been one of the chief causes of failure in our own industry.

"Many contractors do not consider that when investing $10,000 in one piece of equipment he is automatically losing the income of $50 per month or $600 a year which he might receive with no worry or effort from that principal.

"He fails to write off depreciation on his own personal automobile used in business, and, in many cases, the efforts of ten years are represented by an aggregation of worthless junk.

"If such items as the above are included in the cost of doing work, a road contract should show a net profit of from 10 to 15 per cent, depending upon the accompanying hazards such as difficult bridges, treacherous soil conditions and the like."

Another contractor writes. "My advice to the young man starting in the road game would be 10 per cent for profit, and 6 per cent for overhead and personal obsolescence would not be too high, and if there is any element of risk, such as in the road game, he should add 4 per cent to that."

Another contractor quotes, "It is a hard question to answer as to what is a fair profit in highway construction. That depends on what one ordinarily carries in his items of cost. With a number of contractors it is customary to carry all items of operating costs, which includes the various payroll items of operating expense such as equipment repairs, gasoline, grease, oil and various other similar items, and figure what they term a gross profit, after charging off the items mentioned. That means all overhead items, such as bonds, directors' fees, life insurance, officers' salaries, taxes, traveling expenses, etc., also depreciation on equipment have then got to be charged out of the profits. Where one carries their cost accounting in this manner, I would say that a profit of at least 33 1/3 per cent should be figured."

This same contractor writes, "In our manner of cost accounting we charge off everything that comes under the head of operating expense, operating charges, leaving but the one item of depreciation to be charged out of the profits account. Figuring a job in this manner I would say at least 25 per cent should be figured. Where one is accustomed to including depreciation as well as every other charge-off item in their costs, including weather hazard, then of course whatever profit is shown on the balance sheet should be an actual

net profit, and 15 per cent is as low as that should be figured."

From the above expressions one cannot help but note that there is a considerable difference of opinion as to the amount of what a fair profit in highway construction is. We all know that the construction business is probably the most hazardous of any in the country, and because of this I believe that a higher margin of profit should obtain in the construction industry than in another industry that is not so hazardous.

Comparison of Profits With Other Industries.—In looking over the income tax returns for the year 1924, tabulated by the Treasurer's Department, United States Internal Revenue, we find the following:

Manufacturing, including business such as food products, textile products, clothing, leather, rubber goods, lumber, metal manufacture, etc., had a gross taxable income of $54,000,000,000 and made a net profit of $2,649,000,000, or 4.91 per cent. Financing, banking, insurance, etc., had a gross taxable income of $9,441,000,000, and made a profit of $1,061,000,000, or 11.24 per cent. Transportation and other public utilities had a gross taxable income of $10,000,000,000, and made a net profit of $1,291,000,000, or a net profit of 12.66 per cent. Compare this to our own industry.

Out of 13,176 corporations doing construction work in the United States 4,475 of them had a deficit. These 4,475 concerns had a gross taxable income of $425,000,000, but had disbursements that exceeded this gross income and actually lost over $42,000,000, or 10 per cent of their total gross income. The 8,701 concerns of the total of 13,176 that reported a gain had a gross taxable income of $2,213,000,000, and made a net profit of $84,000,000, or 3.8 per cent of the total gross income. Remember that this 3.8 per cent is the average net profit of 8,701 contractors who were somewhat successful during 1924, while the average net profit of all of the 13,176 contractors was only 1.6 per cent.

Conclusion.—In conclusion, therefore, and as one contractor puts it, "There is no 'royal road' either to the best estimating or the prevention of the disappearance of profits. To the close student of the subject, however, this fundamental thought should always suggest itself. No matter how many uncertainties may enter into the preparation of an estimate, the moment that you eliminate or neutralize one of these uncertainties by careful analysis and study, you are correspondingly closer to the actual result than if you guessed at them all."

Study your costs of previous work, use a fair amount of intelligence in preparing your bid, covering labor and material, and a reasonable amount for equipment rental, a proper amount for overhead, allow for contingencies, and add anywhere from 10 to 15 per cent of the total figures thus far obtained for net profit and, in my judgment, in the end you will probably find, because so many unforeseen things occurred, the 10 to 15 per cent that you anticipated making will dwindle to a net profit of around 3.8 per cent, which is that indicated for the 8,701 construction organizations that did not actually lose money on construction work during the year 1924.

Must Build Roads Around Cities

New ways around the congested centers of cities must be provided in all directions and present routes must be completed and improved to carry the increasing through traffic, said Samuel P. Wetherill, Jr., president of the Regional Planning Federation of the Philadelphia Tri-State District, in an address at a recent meeting of the Pennsylvania section of the Society of Automotive Engineers. Indirect and poorly marked by-pass motor car routes now force a tremendous volume of unnecessary traffic to flow into and through the centers of the largest cities of the district, particularly Philadelphia and Camden. Hence new ways around these centers must be provided in all directions and many of the new highways in all probability will be forced through open farm lands to avoid costly destruction of existing improvement, to tie together outlying communities, and to open new territory to development.

The present highway system of radial roads that are now great trunk highways carrying tremendous traffic in and out of the cities was largely determined by early travelers in their journeys from home to market, but not until much later when the country was further developed did intercourse between the outlying towns justify the building of cross-connecting roads. These later roads, built around the center a link at a time, were irregular, disconnected and far from adequate for present needs.

Great express and freight highways are an urgent necessity, continued Mr. Wetherill, who said that the highway system must no longer be permitted merely to grow but must be designed expressly for the purposes it is to serve.

Regarding the Tri-State District the speaker said that it comprises a metropolitan area of more than 3,000 square miles, bound together by common interests and problems but with its affairs administered by 357 different political subdivisions operating under greatly differing legislative powers. Without proper legislative and administrative machinery for securing joint action by these many units, it would be difficult if not impossible to carry out major development projects.

Highway Contracting

From The NERBA

Weather is a big factor in determining the profits or losses of the highway contracting business. A contractor has a degree of control over other factors, but he must take the weather as it comes. It is a big hazard of the business, and bad weather can easily render unprofitable a contract that if carried on under good weather conditions would have shown a profit.

The past two or three construction seasons in New England have been distinctly favorable to contractors as regards weather conditions. Interference with the progress of work by rainy weather has not been harmful. As a gamble, isn't this season likely to be a rainy one, with considerable interference to work? It certainly starts out that way. During the first 25 days of May, rain has fallen on 18 of them. The weather has not been good for those contractors who thought they were going to get away for an early start.

In the old days people throughout New England had great confidence in the weather predictions contained in the Old Farmer's Almanack. That Almanack had a place in almost every household. The useful and entertaining matter published in it was read from cover to cover. It was a reference book of importance. Now-a-days information of all sorts is rapidly disseminated. Farmers and others living in what used to be remote and isolated places now have their autos, their radios, their telephones, their metropolitan newspapers and their government weather reports. Even now, however, we know some people who place more confidence in the Old Farmer's Almanack weather predictions than they do in those of the United States Weather Bureau.

Established in 1793, the Old Farmer's Almanack is still being published. We have examined a copy of the 135th yearly edition, issued for the year 1927. We find that during the first 25 days of May rain or showery conditions are predicted for 10 days, as against the actual record of 18 days. Showers and rainy conditions are predicted in the Almanack for 5 days in June, 5 days in July, 8 days in August, 5 days in September, and 8 days in October. Taking the first 25 days of May as a basis, with rainy conditions predicted for 10 days and actually existing on 18 days, on the same ratio of prediction to fulfillment we may expect rainy weather conditions on 9 days during June, 9 days in July, 14 days in August, 9 days in September and 14 days in October.

The best bet this season would seem to be that there will be considerable interference with highway construction work on account of rain. Don't overlook the weather hazard when you make up your bids!

Two Thousand Years of Road Building

An Address Delivered Nov. 10 at the 1926 Meeting of the American Association of State Highway Officials

By THOS. H. MacDONALD
Chief, U. S. Bureau of Public Roads

One purpose of this paper is to provide a measure by which to form some adequate idea of the real and relative accomplishments of the highway building industry of this nation, and particularly of the membership of this association, past and present.

Another, probably less possible, is to place before the public the long-time view of the problems of highway building and financing, lifting these, for the moment at least, above the many little passing objections and obstacles that hamper progress.

And yet, another, to bring to those engaged in this work a greater enthusiasm and determination, and a deeper confidence in going forward with the policies and the program we now consider the best practice.

A large undertaking to attempt within the limits of a few pages, perhaps, and admittedly so, but the highway engineers and officials must in justice to their work lift their eyes from the day's work to its compounded significance, to turn for the moment from the details of office and field to grasp intelligently just what has been going on in these United States when projected against the progress of the world after two thousand and more years of road building.

And so, too, for the whole highway industry, and even more truly for the general public, because of its control over public policies today in sharp contrast with the one-time power of single rulers so absolute that they alone determined the dimensions of public work. Here is the first and one of the most vivid contrasts between the present and the past. There has been too much recitation of fact from history imposed upon us without intelligent interpretation. To cut away these foggy fictions to permit an understanding of the underlying truth will clear from our minds much rubbish and many inhibitions that have combined to lessen the degree of leadership this great public business demands and must have.

There have been just three great programs of highway building within recorded history that by the major tests of area served and mileage completed may be classed together:

That of the Roman Empire, beginning with Julius Caesar and extending to Constantine;

That of France under the Emperor Napoleon;

That of the United States during the past decade.

From the data it has been possible to examine it has not been possible to determine limiting dates with exactness from the Roman and French periods, nor is it necessary. There will not be entire agreement with the period assigned to the United States. It is hoped with more complete research to fix these periods more exactly, but the difference of a few years either way is not important. To understand the underlying reasons, principles and the results of these earlier great road building epochs is important. To gain from them their wealth of information bearing upon civilization and reasoning by analogy to apply this knowledge wrought out of national experience to the projecting of the long-time curve of probabilities in the United States is most important.

The Roman Road Building Period.—The fact is recorded over and over, and public addresses have innumerable times reiterated that the Appian Way, the first of the great Roman roads, was commenced in the year 312 B. C. by the Censor, Appius Claudius, under the Republic, and extended from the Porta Capena, Rome, to Capua, about 125 miles distant. But we are confused by the assertion that the Via Aurelia, the second paved highway, was built about 242 B. C., or 70 years later. With the growth and extension of the dominion of Rome, road building progressed so that we read,* "The most ancient remarks we can find in the Roman history of the highways made in Italy to which several magistrates afterwards added so much, that in the days of Julius Caesar, the city of Rome was by them joined to all the regions and principal cities of Italy and though Augustus Caesar and the following emperors made extraordinary works there, it was rather to enlarge and repair them than to make new ones from beginning to end, excepting some made by Domitian, Aurelian and Trajan."

Julius Caesar extended the rule of Rome until there was included in the Western Empire the countries around the Mediterranean Sea, France, Belgium, Netherlands, Great Britain and parts of Germany, Austria and Hungary. At the height of his power, he was made Overseer of the Appian Way and expended large sums from his private purse to repair and extend this great highway. The rulers sent from Rome to administer the provinces carried on the work of road building. But a little later we read of Augustus,† "This great and fortunate Emperor finding himself in a settled peace with so many legions (estimated at 173,000 men) on his hands which might be debauched by sloth, thought he could not better employ so many men, dispersed throughout the provinces, than in the making of new highways in all parts of his Empire. . . ." In addition there were drafted for this work the common people, the mechanics and artisans, the criminals and condemned persons, so that,‡ "In short, we may conclude it was not one kingdom, or one region alone, that furnished men to work upon such a vast design, but that all Europe, Asia and Africa, set their hands to it. And that the greatest and most potent kingdoms that once flourished in said parts of the world were employed at it whilst they were subject to the Empire; which can not be said of any other work in the universe."

This work was carried forward sometimes in a desultory way and sometimes on a large scale under succeeding emperors, but it reached its height under Augustus about 300 years after Appius Claudius began the Appian Way and in the decade before the birth of Christ.

The Napoleonic Road Building.—A brief word is necessary to bridge the Dark Ages (500 to 1150 A. D.) and the Middle Ages into the eighteenth century. With the decay of the Roman Empire the world road system as such broke down, although quite different conditions prevailed in different countries. Religious pilgrimages, the Crusades, the journeys of the secular rulers and the high dignitaries of the Church leave some record of the use of trans-State and transcontinental routes, but the records of commerce are meager. The general tendency was all toward feudal government which resulted in neglect and the actual tearing up of some of the ancient roads as a method of protection. Also, not only the roads but the magnificently built public and private buildings were wrecked to provide building materials. During this period ancient Rome was ravished to a much greater degree to provide building materials and metals than by conquest, fire or other causes.

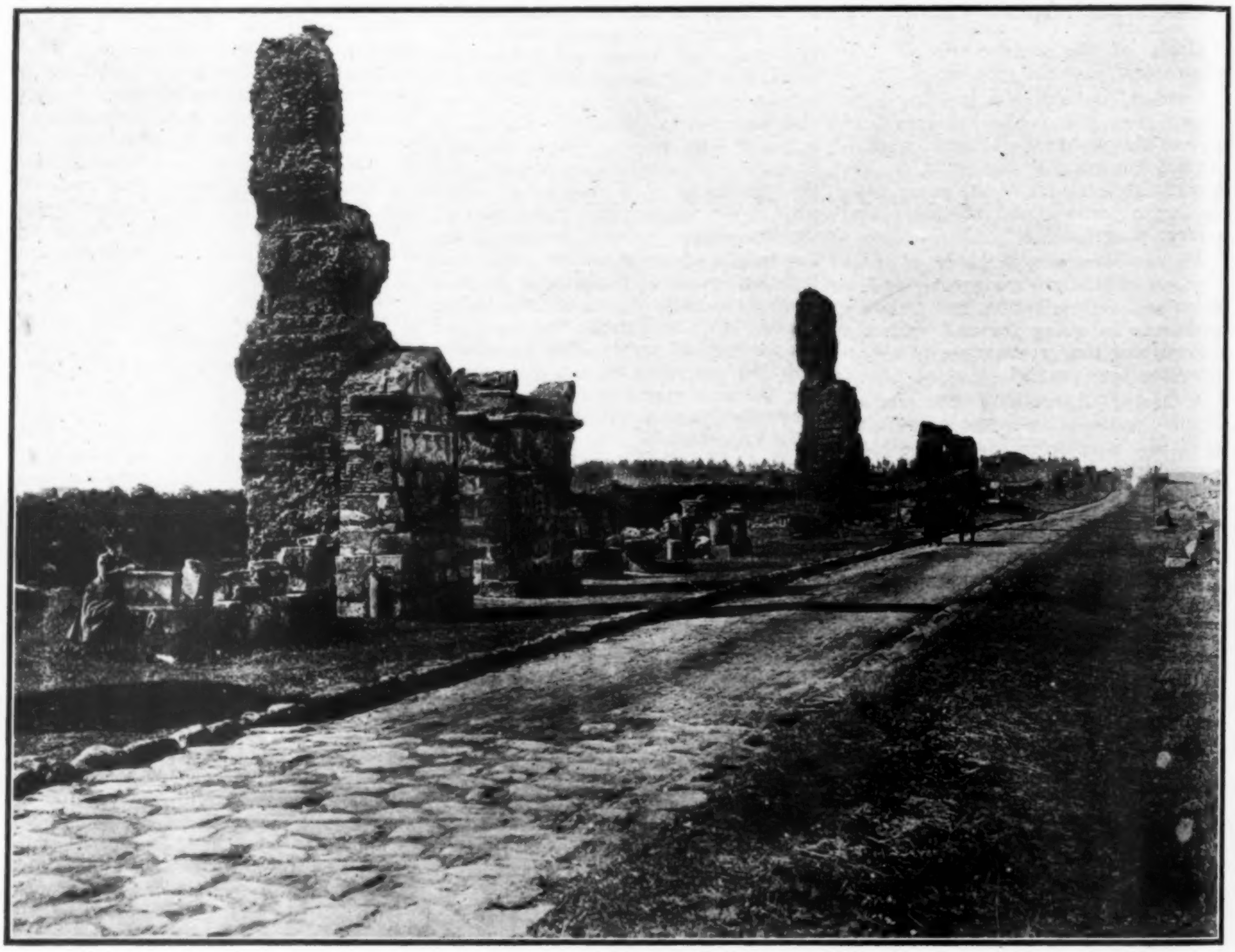
Napoleon became first consul of

*Bergier, p. 35, History of Highways.

†Bergier, p. 42.

‡Bergier, p. 47.

France in 1799 and began at once to build a system of national roads. In 1804 through a plebiscite the people by an overwhelming vote decided he should become Emperor, and that year before the high altar of the Notre Dame Cathedral he placed a golden laurel wreath upon his own head. Also he crowned himself king at Milan of the monarchy of North Italy. Thus at the beginning of the nineteenth century, a large part of the same area that had been ruled by Rome, 12½ centuries later was again brought under an Empire, this time that of France. The Corps des Ponts and Chaussees had been established in 1796, and was composed of trained engineers through the workings of the earlier established technical schools. So when the Emperor demanded and vigorously supported a big program of road building, large accomplishments were possible through the available organization. M. Prony, the Director of the Ponts and Chaussees, described as an engineer of first rank, drove into execution this work. From 1804 to 1813, the expenditure for roads and bridges from the national treasury is placed at 300 million francs. On December 16, 1811, a decree was issued which established a uniform system of highway administration the general principles of which have remained unchanged. This decree divided the roads into imperial and departmental routes, and fixed financial responsibility upon the Federal Government and the Departments. It designated 14 imperial roads of the first class leading from Paris to the principal cities of the frontier, 13 imperial roads of the second class from Paris to the less important cities on the frontier, and 202 roads of the third class joining interior cities, a total of about 17,000 miles. The departmental roads numbered 1,165, in all about 12,000 miles. These national routes included the Mont-Cenis, completed in 1805 to connect Paris with Turin, and the Simplon, completed in 1807 to connect Paris with Milan, Rome and Naples.



A Modern View of the Appian Way—The Most Famous Road of History.

How the Older Programs Differ from that of U. S.—In an incomplete, imperfect way these facts present the only great road building programs that may be compared with that with which the United States is now engaged, but their aspects are very different than we have been led to believe. Both the Roman and the French systems have come down through history as military highways. On the contrary the greatest expenditures were made and the most extensive mileages built after the boundaries of both empires had been extended to their greatest dimensions. Certainly these roads were used for military movements, but both the Emperor Augustus and the Emperor Napoleon threw their energies into road building to make possible the administration of a great empire, to stimulate commerce and to provide food sufficient. Napoleon said, "he feared popular insurrections due to economic causes though he was not afraid of political risings." In other words, a transportation system, adequate and complete, is a fundamental requirement of a nation large in its physical dimensions. On this basis we must, in our conception, link our railroads and motor vehicles and highways. Together they supply the most adequate, most efficient transport system any like area in the world

(1) An Experimental Bituminous Road in France. (2) The bridge over the Marne at Chateau Thierry. (3) Constructing a Stone Block Pavement at Chalons, France. (4) The Rebuilt Village of Verdun. (5) The Paris-Meaux Highway, an Oiled Macadam Surface. (6) Typical Traffic on the Brussels-Namur Road, a Concrete Highway. (7) A Highway Experiment in Denmark. Several Types of Surface Are Laid in Parallel Strips and the Traffic Is Directed to Take One or the Other, According to the Character of Tires and Other Characteristics of the Vehicles. The Sign over the Roadway Indicates the Proper Path. (8) La Voie Sacree (Sacred Way), France. (9) Along the Baltic Sea, Copenhagen, Denmark. (10) A Granite Sett Pavement on the Brussels-Namur Highway, Belgium.

possesses or has ever known.

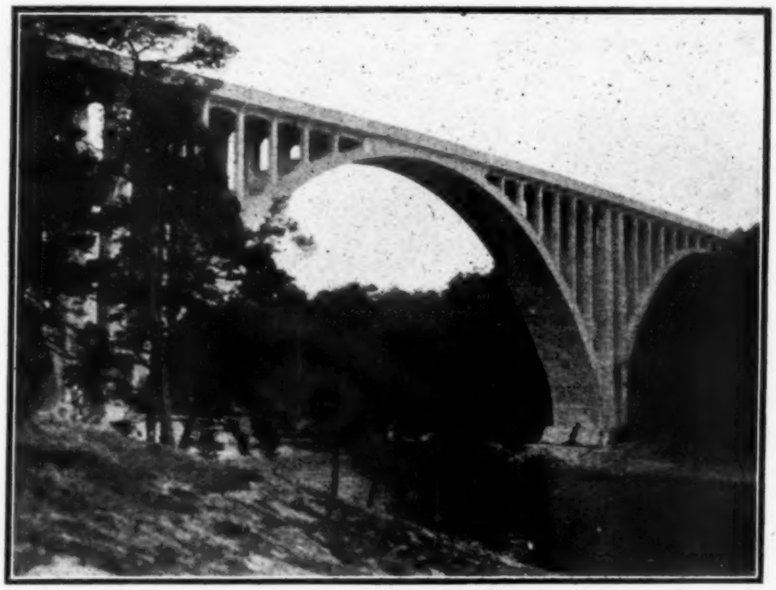
In the Empires, authority from a single source was supreme, in this Democracy we are dependent upon co-operation between the States themselves and between the States and the Federal Government to complete an orderly system of highways that will permit traffic and commerce to flow uninterrupted. In a major degree also we must depend upon co-operation, not legislation, to establish coordination between railway and highway.

More than 125 years ago France placed her highways under competent technical direction and provided for a system of technical instruction to train men. Generally speaking, the technical equipment of our highway engineers is very good and constantly improving. When fitness for the position and integrity of character are made the first requirements for appointment to highway departments, there will be no more highway administration scandals. Until this is done we can hardly fail to have at least isolated cases of a breakdown of efficient and honest administration.

Present Day Conditions in Foreign Countries.—Of chief interest to us in the United States is the effect that past history has had upon present day road conditions since it may help us to see further ahead and certainly the experiences of civilization in the older countries ought to have much of value in formulating broad plans for the future.

Italy, with a relatively small nation in area, of about 120,000 sq. miles, has a population of 39,659,944. The population has clustered thickly along the world old lines of highways, has crowded in upon the rights of way, and there are many villages. There is a large amount of foot and animal drawn traffic, but the maximum flow of automobile traffic reported near the population centers is 3,300 vehicles in 15 hours. The Italian Premier, Benito Mussolini, in his final address to the Road Congress stated, "Italy has a great road problem to solve; new roads necessary to promote her agricultural life, to facilitate her commerce, and finally, arteries necessary for international tourism in order to render her beauties accessible. She possesses, moreover, a conspicuous road patrimony formed during many centuries by the work of countless generations." Apparently the surfacing and maintenance problems in Italy are of first import, but the new alignments that will be necessary, or perhaps even new rights of way, in many cases present, certainly, "a great road problem to solve." So serious is the problem of alignment and widths of highways leading from the large population center of Milan, that about 50 miles of toll motor roads have been built under Governmental franchise by private corporations.

France and Belgium have a wonderful heritage in the systematic plan that was laid out and begun prior to, and developed and completed since, the Napoleonic Decree of 1811, so that the layout and classification of the highway systems in these countries on a nation-wide basis for uniformity and adequacy of planning are perhaps superior to anything in any like area. The Polytechnic School and the Ecole des Ponts et Chaussees supply the highest ranking engineering graduates for the highway work. In both these countries there is a considerable mileage of main routes paved with stone blocks but the surfacing problem on long mileages of macadam is important. A series of experimental roads have been built near Paris for testing various types of concrete slab and bituminous construction, as well as surface treatments.



A Graceful Arch at Stockholm, Sweden.

In Austria and in Szechoslovakia also the surfacing problem on the main roads is of first importance. There are in existence some splendid highways which we are informed date back to the time of Marie Therese. Near Vienna and again near Prague experimental roads are under construction in which both the bituminous mixed types and concrete slabs have been made. These appear to be the first roadways which have been laid in these countries corresponding to the standard types of pavement in general use here. We were informed that following establishment of a school for technical instruction in France, a school was established in Prague, and whether from this school emanated the standards that were set up for the national road construction is not made clear, but in any event some of the best roads, those more nearly corresponding to the best modern standards in alignment, substantial proportions, width and adequacy, are found near Prague. Where such roads existed an adequate modern surface will complete roads of the highest class.

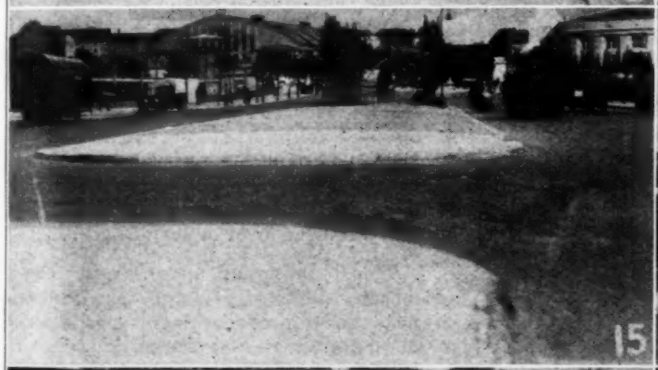
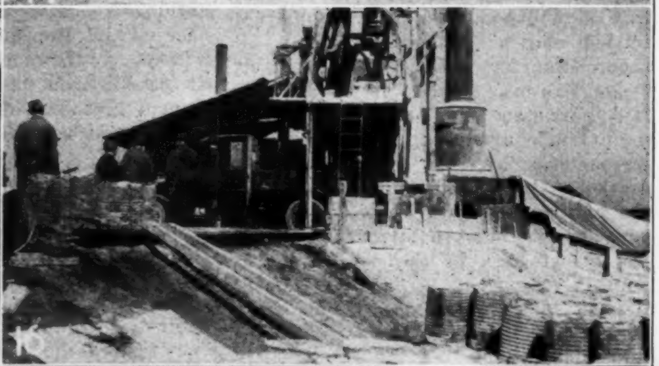
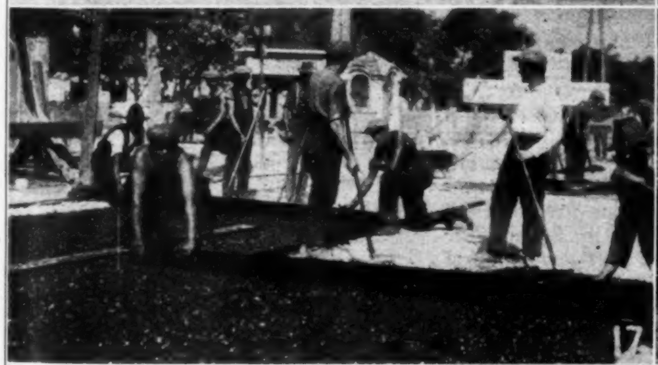
In Germany the road work has been carried on by the individual States rather than through any central direction, so that the highway service now is on a State rather than a national basis. The Federal Director of Traffic states that the major problem is to provide national routes. An experimental track, similar to that used in the Pittsburgh and Arlington tests, has been built by one of the States for testing the relative values of the various types of construction that may be used.

In Great Britain, with an area of 50,000 square miles and a population of 37,000,000 people, the traffic problem has become acute within and between the big cities. The Ministry of Transport has built some arterial roads to relieve bottle necks and to establish through lines of communication. Where these have been completed as parts of established routes they are carrying a very heavy traffic and have afforded wonderful relief. This work, however, was taken up at the particular time to assist in providing employment, and a part, at least, did not accord with the views of the Ministry of Transport. Where entirely new roads have been opened, width of roadway, alignment and engineering features show splendid vision in providing for the future. But in order to make them fully effective much more work and further expenditures are necessary and this is the difficult problem.

By-Pass Roads in England.—The feature of the work here which deserves the closest attention on the part of the engineers of this country is the new roads which are being laid out to by-pass the congested streets of villages






(11) Typical Cart Traffic at Como, Italy. Note the Lack of Observance of Any "Rule of the Road." (12) A Surface-Treated Experimental Road at Prague, Czechoslovakia. (13) Laying a Bituminous Concrete Surface as an Experiment at Prague, Czechoslovakia. (14) "Uncommon Carriers" at Prague. (15) The Berlin-Potsdam Motor Toll Road in Germany. Construction Was Begun by the Kaiser Before the War as a Royal Road to the Potsdam Palace. (16) An Austrian Asphalt Mixing Plant. (17) Laying Bituminous Concrete on an Austrian Highway. (18) Grading Operations on a Swedish Road near Stockholm. (19) The "Autostrade," Italy's Toll Road from Milan to Como. (20) A Toll House on the "Autostrade."

and towns. A typical illustration of the fact that human nature is very much the same the world over, is the record of the fight made by one of the towns established possibly during the time of William the Conqueror to prevent a by-pass being constructed around the town to take the traffic out of the narrow crooked streets of a very densely populated district. The problem of new bridges over the Thames and opening of new traffic ways in London County present problems of first magnitude which the Ministry of Transport is now courageously attacking. It is difficult for us to realize in this country the obstacles imposed by the tremendous weight attached to personal and property rights in Great Britain. To illustrate: Because in the olden days the city of London collected customs at its gates, farmers having supplies to sell formed the habit of stopping just outside the gate and the people came out from the city to buy. So gradually there was established a market. At the Aldgate a hay market was established. As the population settled and as villages grew up all around the city of London, which itself is just one mile square, the hay market still persisted and today one of the main traffic arteries to the docks and warehouses now runs through this old market. On certain days of the week the hay carts are parked from curb to curb leaving only room for passage of the street cars in the center. It is doubtful if any area in this country presents as complex and difficult problems as the London County area in the immediate vicinity of the city of London, many of which emanate from ancient rights, customs and traditions. The country roads are largely of macadam construction, and offer most delightful recreational opportunities, but they can not supply the facilities necessary to heavy traffic arteries.

In Sweden experimental roads of different types have been built near Stockholm and a very active debate is taking place as to the best types of road construction. But the real problem at present is to re-align, widen and grade the old roads to offer proper facilities for motor traffic.

In Amsterdam, as would be expected, the foundation problem is very important, but high technical skill has been exhibited in the construction of roadways. Some of the best asphalt pavements in Europe are in this city.

Denmark is supplied with an arterial road system with ample right of way and a large mileage of stone block pavements. There are also experimental stretches of road near Copenhagen and there is a departure from the usual type of such roads in that parallel lanes of different materials have been built and the traffic is divided between the pneumatic, solid rubber and steel tired vehicles, each taking the lane provided for that particular type. One of the notable types of traffic here is the bicycle. In a population of 3,289,183, we are told there are one and one-quarter millions of bicycles, and apparently most of these are on the road at the same time.

Comparison Between U. S. and Foreign Countries.—Considering the rural highways there are two outstanding contrasts between the United States and the countries here touched upon, the character and extent of highway traffic and the highway finances. The motor passenger car is regarded still, as in an earlier time in the United States, as a luxury and treated as such, and so it is a luxury. The prices of new cars are high, though there is a very rapidly growing production of lower priced types. Motor fuel is high. Annual taxes are high. Consequently the development of the use of passenger cars in any of these countries can not be remotely compared with the use in the United States. Driving over the national roads of France for example, once outside the immediate influence of a large city the motor traffic is so small, in fact all traffic is so limited, that it is evident there is a very different kind of life prevailing in the rural communities than that which exists here. While there is much very short radius motor traffic in the large cities, the people generally have not discovered the potentialities of motor transportation either for business or recreation. They have not yet found the way to know their own countryside, their country's scenic attractions or the commercial advantages of fast, convenient transportation. From a limited viewpoint, conditions appear very much as they did in this country 10 or 15 years ago, just before the avalanche of motor vehicles enveloped us. A similar turning to the use of motor vehicles will come but probably it will be somewhat reversed. Our private motors came first and the public later. Possibly in Europe the public motor vehicle may develop first in a large way, both busses and commercial haulers, to be followed by a large use of the private motor.

Financial Aspects of Foreign Highway Work.—Everywhere the highway officials are laboring under the severe handicap of lack of funds. When it is remembered how many of the European countries finance the entire cost of the national highways, it is easily understood, with the national treasuries and currencies in their present conditions, what great difficulties stand in the way of renewing and rebuilding their highways to modern standards. It is undoubtedly this situation that has turned Italy toward a favorable consideration of the motor toll road, privately owned.

In view of the demonstrated capacity of improved highways to stimulate commerce and to make possible new lines of profitable production, it came as a shock when we were informed that a bond issue for much needed rehabilitation of important highways in one country had been forbidden because such expenditures are not capable of producing a direct return—proof unanswerable that in high places modern highway transport is believed a luxury and not a commercial necessity.

Simple but important conclusions shape themselves with the present day highway conditions of Europe projected against the background of the highway history of the two thousand years since the beginning of the Appian Way, a section of which may be seen today crossing the Campagna, toward the Alban hills, preserved as an interesting and valuable historical record; but the traffic is carried over another highway and itself has about the same relationship to modern road building as the skeleton outlines of the cliff dwellings in our West have to modern architecture. The likeness to the original is about the same in each.

Highways a Thing of Service.—Service requires changes; they must themselves change; and to provide adequate service over the largest possible mileage and at the least cost is the requirement just now, and there is abundant evidence that this has always been the policy when efficient highway service was required over a large area.

This building up under service, only another name for stage construction, has always prevailed. Our roads must be maintained and strengthened, certainly and constantly, but this has always been the case. Referring again to the Appian Way, we have the record of its being repaired and rebuilt for at least 500 years although the first section was, we read, so expensively built as to wreck the Roman treasury. History asserts loudly the fact that once he has set traffic going over a highway, the work of the engineer has just begun.

As to standards of construction, there again is fixed only the one unfailing measure, that of adequate, satisfactory service at minimum annual cost. No more, no less, is necessary.

On the other hand, what tremendous support history supplies for correct principles of administration. France and other countries which for a long time, from 100 to 150 years, have had an adequately planned national system with the roads classified in accord with their importance and with a highly qualified technical corps to carry into execution the administrative principles, have today a heritage of untold value. Their national roads have right of way widths, alignment, gradients, compacted road beds and fine bridges. They lack in many sections top surfacing suitable for heavy motor traffic which will be supplied as it becomes possible.

Low Cost Improved Roads

Extracts from a Progress Report Presented at 6th Annual Meeting of Highway Research Board

By C. N. CONNER
Highway Research Board, Washington, D. C.

The object of the investigation is to collect, correlate and present information in order that conclusions may be drawn and comparisons made on types, costs, traffic capacity and suitability of intermediate type road surfaces under varying conditions of soil and climate.

It is not the intention to make it highly technical in character or to delve deeply into the mechanics and chemistry of aggregates and admixtures, but rather to make a wide general survey of conditions as they exist in actual field practice or experimental sections.

The scope of the survey includes:

1. Treatments and surfacing of loam, clay, top soil, sand clay, marl, lime rock, sand, cinders, slag, gravel and stone;

2. The admixtures for these treatments include lime, calcium chloride and other chemicals or by-products, road oils and asphalts, tar and Portland cement;

3. The climatic conditions include those of the southern, middle and northern states as well as some of the more arid regions;

4. The types of surfacing will include chemical soil treatments, hot and cold surface treatments with tar, hot and cold surface treatments with asphalts, surface treated and penetration macadams, modified sheet or sand asphalt, using local materials, bituminous concrete, using local materials, natural rock, asphalts, portland cement and local sand mixtures.

These types of surfacing will be considered in connection with the different types of base on which they have been used, but will not include standard base courses of portland cement concrete, plain and reinforced concrete.

Field inspections have been made during parts of July, August, September, and October, 1926, in the states of Maine, New Hampshire, Vermont, Rhode Island, in Long Island, New York, New Jersey, North Carolina and Virginia.

It was gratifying to learn and observe the success which has followed the necessity of furnishing highway surfaces at a comparatively low cost. This, naturally, has been accomplished to a large extent by using local materials.

The types inspected included calcium chloride treatments of gravel, asphaltic oil treatments of gravel, tar treatments of gravel, asphaltic concrete on gravel or stone base, sheet asphalt on gravel or stone base, bituminous macadam on gravel or stone, marl base with tar surface treatment, marl base with sand asphalt top, and sand asphalt.

Other types of surfacing have been studied but not investigated in the field, such as the oil-bound surfacing of stone roads, lime and portland cement treatments of clay and portland cement mixtures with local sand.

Lime Treatments of Earth Roads.—The principal tests to determine the effect of treating earth roads with lime were conducted by the Engineering Experiment Station at the University of Missouri beginning in 1924, about the same time field tests were started by the U. S. Bureau of Public Roads in Iowa and South Dakota. Since that time Ohio State University, University of Illinois, and Wisconsin State Highway Department have entered the investigation, each with a particular problem.

This investigation has consisted of laboratory work, together with actual field tests, and while the experiments are not yet completed, several things have been discovered which might be of interest here.

In making the lime treatment hydrated lime is thoroughly mixed into the road soil to a depth of 6 in. by plowing and discing. To obtain the best results the road should be quite dry when the treatment is made, in order to get an intimate mixture. The road is then dragged to the proper cross section and opened to traffic which quickly packs it.

It is stated that lime treatment stabilizes heavy clay and silt soils. These soils lose their stickiness and plasticity, becoming granular in structure, which renders them capable of sustaining normal traffic loads without failure when wet.

The field tests with lime treatment have used various percentages of hydrated lime ranging from 2 to 5 per cent by weight and from 3 to 9 per cent by volume. The depths of soil treatment have ranged from 2 to 6 in. with the majority of them at 6 in.

Among the possibilities looked for in these tests are:

Where traffic is heavy enough to warrant a better road, the subgrade may be treated with lime and the surface covered with a thin layer of crushed stone or gravel. Without the lime this thin layer of surfacing material would soon sink into the clay and disappear; but with the increase in stability and loss of plasticity due to the effect of the lime, the thin layer of gravel or crushed stone is expected to remain on top.

It is claimed that maintenance on a lime treated road is simplified in several ways. The soil loses its stickiness and is not picked up by the wheels of vehicles. This keeps the road from becoming rough. The increased stability of the soil prevents the wheels of vehicles from cutting ruts after the surface begins to dry. The lime treated road dries out faster and can be dragged many hours sooner than the road without lime. The treated soil mulches more easily under the drag, making it easier to obtain a smooth riding surface.

But whether or not these treatments are to become an economic success in competition with local sand and gravel as surface stabilizers has not been proved from the results so far obtained.

Calcium Chloride Treatments. — In many states and localities where local gravel, sand clay, or top soil are available a large mileage of surfacing has been constructed, but due to the intensity of traffic in summer and dry weather the dust nuisance has become a serious menace.

As is well known, when traffic reaches 300 to 500 vehicles per day the surface often becomes corrugated and an appreciable amount of surfacing material is lost.

Insufficient funds to lay a hard surface highway or even oil or tar treatments have forced these localities to find a palliative in order to carry their summer traffic.

In New England both Vermont and Maine have used this material with a reasonable amount of success for the purpose intended.

During 1925 Vermont treated over 2,200 miles of gravel road and Maine has about 500 miles.

The amount of calcium chloride applied per year varies between ½ and 1½ lb. per square yard in these states and is applied from a lime spreader hauled by a truck. Other trucks are put in use to bring up additional supplies as the work progresses.

It has been found that dust and corrugations are reduced but that pot holes will occur, which may be remedied by patching with fresh gravel.

The calcium penetrates as deep as 1 in. in places, in others scarcely at all. This variation is due to the porosity of the surface material and amount of calcium chloride applied.

The opinion in Vermont is that the gravel should contain a fair amount of binder, say, up to about 25 per cent.

These treatments do not effectively carry through the winter; however, there is a slight evidence that some benefit exists in the following spring from the previous season's treatment.

The total costs per mile per year seem to vary between $100 and $300, the variation being due to the porosity of the soil, intensity of traffic and amount of applied chloride. The cost of application in Vermont is 17 per cent of the cost of the delivered material.

The final report will contain data from other states including Michigan and Minnesota where it is understood these roads are carrying 1,000 to 3,000 vehicles per day.

Sand-Oil Surfacing or Sand Asphalt Layer Method.—Although this type of surfacing has been satisfactorily used in Long Island, New York, for at least 10 years, it is only within the past few that its possibilities for similar soil conditions in other localities have become apparent.

We now find this or a similar surfacing being tried out in actual service in several of the southern, middle, and far western states.

Its economy and success depend largely upon the proper selection and manipulation of the local materials, as well as performing the construction and maintenance under suitable weather conditions.

The surfacing in Long Island consists of a mixture of road oil; (Texas 55) mixed in place by dragging and traffic with local sand or sand loam, after successive applications of the oil and aggregate.

As a result of a field survey on some 400 miles of this work in Long Island a few observations will be made in this report:

The subgrades were in general sandy loam over sand or fine gravel.

Local materials as aggregates were used entirely.

The surfacing widths varied from 9 to 75 ft.

The thickness of mixed surfacing varied from ½ in. to nearly 6 in.

Crown ranged between ¼ and 1 in. to the foot.

Wider sections showed less fatigue than the narrow ones.

Two treatments are necessary the first year for satisfactory results.

One treatment each succeeding year is in general sufficient.

Some of these roads it is estimated are carrying as high as 5,000 and 6,000 vehicles per day in the summer season.

These surfacings are said to cost from $800 to $1,500 per mile for the first year using an 18-ft. width and from $300 to $800 for each succeeding year.

In many cases the surfacing is protected during the winter months by pulling in sand and loam from the ditches to a depth of about ½ in. over the entire surface. This is done at the beginning of cold weather, usually in October.

It must be borne in mind that the local material as found in Long Island is well adapted to this type of construction.

Beginning in 1924 oil treatments of gravel roads were started in New Jersey.

The same grade of oil is being used and similar methods of construction and maintenance are being employed as in Long Island.

Good aggregates for cover material are easily procurable locally.

Inasmuch as skill in construction and maintenance are not as highly developed on this particular type in New Jersey the results at present are not as gratifying as in Long Island.

There is every reason to believe that this sand-oil type will be satisfactorily developed as the local materials are excellent.

The costs in New Jersey are about the same as in Long Island.

This same type of construction was started in North Carolina in 1925 after some experimenting in 1924.

The oil treatments were applied to sand clay, top soil and gravel roads.

At first oil was used for the prime coat and following treatments. This was later changed to a prime treatment of tar followed by a quick curing asphaltic oil.

Something over 400 miles of this work have been constructed in that state.

The results in general have been very satisfactory especially as to improvement in smoothness of riding surface, increase in traffic-carrying capacity at all seasons and abolishment of dust.

Some of this work cost as high as $2,500 per mile for a treated width of surface of between 18 and 21 ft. for the first year.

It is very probable that the cost can and will be reduced for succeeding years to about $700 per mile on surfaces previously treated.

These treatments were not entirely satisfactory on certain sand clays, on worn-out fine gravels and in places where the cover sand contained undesirable foreign elements.

It is probable that these roads will satisfactorily carry from 1,000 to 1,500 vehicles per day and possibly more.

The sand-oil or gravel-oil road has been tried out in other states and in Mexico with varying degrees of success and there is great probability that, with careful study and intelligent selection of local materials as well as proper construction and maintenance, the sand-oil road will become much improved in the next few years.

Tar Treatments of Gravel.—In Maine, New Hampshire, Maryland, Virginia, Wisconsin, Michigan, and several other states, the use of tar on gravel roads has met with considerable success.

As in the case of the oils, the most successful results have been achieved when great care was taken in the selection and preparation of the surfaces to be treated, as well as care and pains in the construction and maintenance.

Forced by the necessity of carrying its own traffic and that of a large tourist traffic in the summer months, Maine was probably the first state to make a success of tar-treated gravel surfaces. After many of the details and methods had become established, other states took up this method of tar treatments of gravel.

There are about 550 miles of tar-treated gravel roads in Maine whose climatic conditions are probably as severe as any state in the Union.

Depending on weather and traffic these roads at times break up in the fall or winter of each year. This breaking occurs at a period of thawing on warm days following a period of freezing weather.

In Maine, it is the policy to scarify and reshape these surfaces each year. The old tar mat, however, is not wasted but is broken up and spread again over the gravel surface, compacted by traffic or rolled and then retreated with tar.

On account of the heavy freezing and poor subgrades, a sub-base of from 2 in. to 12 in. of gravel or stone is laid before the standard gravel surfacing is placed. Gravel sub-base is quite generally and satisfactorily used in New England under all types of surfacing, including portland cement concrete.

The gravel surfacing proper has a compacted thickness of from 8 to 11 in. The tar mat has a thickness of from ¼ to 1 in.

The tar surfacing complete costs in Maine, for an average of 17-ft. width of surface, from $800 to $1,500 per mile per year, the average being about $1,100.

This includes considerable patching, which is done by mixing coarse sand or fine gravel with tar either by hand or in a small power concrete mixer, hauling and placing as required.

The annual scarifying and reshaping process results in a comfortable and smooth-riding surface.

The methods in New Hampshire are similar to those in Maine except for the annual clarifying. While this is done to some extent it is not followed as extensively as in Maine.

The annual cost per mile in New Hampshire is about the same as in Maine on the same type of construction.

New Hampshire has about 1,000 miles of this type of surfacing.

Virginia has and is constructing tar-treated gravel roads. The surface treatments are costing from $1,100 to $1,500 per year for the first year.

Details from other localities are not available for this report, the final report, however, will include them.

Veneer Bituminous Macadam.—It is somewhat difficult at times to classify the various low-cost roads by name, but at the risk of being misunderstood the next type to be considered will be the veneer bituminous macadam.

This type of surfacing consists of a layer of crushed stone placed upon and keyed by rolling into the surface of a sand clay, top soil, or gravel roadway.

It is then penetrated with bituminous material and completed in practically the same manner as a penetration macadam surface.

An experimental stretch of this was laid near Raleigh, N. C., more than three years ago and is still rendering good service with a traffic of about 1,400 vehicles per day.

Another road of practically the same type was laid near Richmond, Va.

The first cost is about the same as for bituminous macadam surface; the annual costs have been about the same as for bituminous macadam under equal traffic.

A similar type of construction was completed in Oregon. The roads to be surfaced consisted of old water bound and also traffic bound gravel or crushed stone. It was found that the ordinary methods of maintenance were not sufficient to hold the surface intact and free from corrugations.

After experimenting for a number of years with clay binders the Oregon engineers developed the method of incorporating the binder with the surfacing material of crushed stone or crushed gravel by the process of thoroughly mixing the proper proportion of carefully selected binder with the stone or gravel by means of heavy blade road machines which mixed the material thoroughly.

In most cases water was applied by means of sprinkling trucks so that the resulting surface was really a stone clay or gravel clay roadway veneer.

The blading and traffic made this into a dense hard surface. After this surface had been maintained under traffic it was wet down with water trucks and the moistened surface shaved smooth and regular with a road machine.

It was then thoroughly cleaned of dust and oiled in two or more applications. About 0.3 gal. per square yard for the first and 0.2 gal. for the second.

It is stated that the total cost per mile 18 ft. wide for preparing and oiling these roads when in actual condition to receive the oil should not exceed $500 per mile.

With a normal amount of maintenance this road would probably carry 1,000 to 1,500 vehicles per day.

Retread Treatment.—In line with this retreatment of old surfaces is the retread treatment as it has been called.

This consists of shaping and patching up the old road surface, placing on it a 2-in. layer of ¾-in. stone, smoothed out with a blader and treated with a ½ gal. per square yard of bitumen, then rolled if a roller is available. Traffic may be let over it, but if this is done the road should be bladed and dragged for from 3 to 5 days. This keeps the ruts filled and maintains a smooth and regular surface.

At the end of the fifth day, or when the surface begins to set up, blading is stopped.

The surface is again treated, this time with 0.3 gal. of the same material and covered with chips or coarse sand.

This method has not been investigated in the field, but if it is as satisfactory as claimed it should be of service in many communities.

In West Virginia the graded earth and shale surfaces are first surface treated with either road oil or tar, and then it is proposed to cover with stone passing the 1½-in. screen.

It is expected there will be some heaving and breaking during the winter when frost is coming out of the ground, where surfacing is thin and clay is abundant.

After the first year they propose to scarify the surface to the depth of the stone and then blade it to each side of the road in windrows. Between the windrows a new 2-in. layer of stone will be spread and penetrated as before. The two windrows will then be bladed back on this new layer and the same process of machining repeated as in the first year.

It is expected that the annual cost for a 16-ft. width of roadway will be between $2,000 and $3,000 and that by the end of the fourth year a good bituminous surface will have been built.

This and similar experimental construction on low-cost improved roads are attracting deserved attention.

In Pennsylvania the oil bound broken stone surface on stoned road consists of a surface course 2 in. thick after compression.

It is composed of ¾-in. stone, which passes a 1¼-in. screen and is retained on a ⅝-in. screen.

The stone is dumped and spread, in accordance with standard specifications for macadam, into a smooth and regular surface on the old stone roadway.

It is then rolled with a 10-ton 3-wheel power roller.

Bitumen ranging from 0.3 to 0.4 gal. per square yard is applied and the surface rolled again to a uniform cross section and allowed to dry from 24 to 36 hours.

The second application of bitumen material is then applied at the rate of from 0.2 to 0.35 gal. per square yard.

Where a dull-brown color exists it is necessary to apply a larger amount of bituminous material than where an excess amount of bituminous material shows on the surface from the first application.

After the last application, the rolling is continued until the surface is thoroughly compacted.

"Rawhide" Surfacing. — Among the patented types of surfacing is the "rawhide road."

The general principles of the type are similar in effect to the sand-oil roads.

The main difference is the employment of a special 10-ton tamping roller to mix and compact the soil and asphalt and in a short period of time rather than waiting for traffic to do the compacting.

The wearing surface is built up in successive layers by mixing the existing soil road surface with the applied asphalt until a compacted thickness of from 4 to 6 in. is obtained.

It is claimed that this road for an 18-ft. width can be built for from $5,000 to $10,000 per mile.

Marl and Lime Rock Base with Bituminous Surface.—When local material of marl or lime rock are available a base course of 6 to 8 in. thick and covered with a bituminous surface has provided a low-cost improved road.

In some South Atlantic states deposits of these materials are found in close proximity to the road locations and can be more economically used as a base course than shipped in materials.

In southeastern North Carolina there is quite a large mileage of marl base.

This material is hauled from the pit, and the larger pieces screened out and crushed; all of the materials from some pits requires crushing.

It is then hauled to the road, suitably dumped, spread, machined with a blader, and firmly compacted by rolling.

Timber side forms on edge and equal in depth to base course, if set to lime and grade, will aid in securing a better job.

Timber forms left in place where lumber is cheap have resulted in excellent work.

When the base has dried out the surface is finally trued up and cleaned. It is then ready for the bituminous surfacing.

In Florida there are three principal classes of local material used in this type of base course—Florida lime rock, ojus rock, and coquina rock.

Ninety per cent of the material is required to pass a 3½-in. screen and not less than 30 per cent retained on a ¾-in.

The specifications require temporary side forms, sprinkling, rolling, harrowing, and machining until the entire depth of crushed stone is bonded and compacted into a dense and unyielding surface true to grade and cross section.

These surfaces, after traffic has searched out the weak spots, are prepared and treated with various types of bituminous surfacing.

For lighter traffic a surface treatment of bituminous material and a coarse chip or coarse sand is used.

Another type is bituminous macadam, using hard crushed stone.

Asphaltic concrete using local materials has been satisfactorily employed, as has also sheet asphalt with a binder course.

Sand Asphalt and Bituminous Concrete, Using Local Materials. — The coastal plain of the Atlantic seaboard does not have an appreciable amount of local hard rock, but in many instances it does have large areas of fine or coarse sand.

Massachusetts, in what is known as the Cape Cod section, took advantage

of this fact some 15 years ago and started building bituminous concrete roads, using the local sands.

On account of the excellent drainage of the sand subgrades many of these older roadways are still entirely serviceable.

The earlier surfaces were laid 4 in. compacted thickness, but this method has now been changed to two courses of 2 in. each.

In the earlier pavements no side forms were used, in recent years temporary side forms of 2 x 4 lumber are used for the top course.

The bituminous concrete is rather open and carries a low percentage of asphalt. It is considered necessary at times to ship in stone and filler dust.

After the first year these surfaces are treated with a light seal coat of road oil and sand.

At the present time these pavements are costing about $10,000 per mile for an 18-ft. width.

Some of these roads in Massachusetts are carrying as high as 2,500 vehicles per day.

The first sand asphalt pavement in North Carolina was constructed nearly five years ago.

It is similar in some features to the Massachusetts work on Cape Cod; the principal difference is the use of a much finer sand.

The 3-in. base course is composed entirely of local sand and asphalt.

The top course contains local sand, asphalt and filler.

Side forms of cypress or pine are set on edge to line and grade, firmly staked and left in place.

The pavement as originally laid had a 3-in. base course and a 1½-in. top.

On account of some difficulties in cracking of top coarse and lack of band between top and base, some experimental sections were laid in 1925 and satisfactory results were obtained by making the following changes:

The surface of the 3-in. base was treated with a squeegee coat of hot asphalt immediately before placing the top and the top was increased in thickness from 1½ to 2 in.

Sand asphalt is now being laid in Delaware in the southern part of the state where large quantities of sand are available locally and where subgrade conditions are suitable.

Contract prices in North Carolina on this work have varied from about $1.40 to $1.90 per square yard, including side forms.

It is probable that this surface can be built for about $18,000 or less per mile for an 18-ft. width.

It will easily carry 1,500 to 2,000 vehicles per day.

Gravel Base and Stone Base with Bituminous Concrete and Sheet Asphalt Surface Courses.—These all-year surfacings have given good service in widely separated sections of the United States.

From the field investigations so far it is evident that their traffic capacity has been exceeded near some of the larger centers of population.

This is more noticeable in the bituminous concrete than in the sheet asphalt.

The sheet asphalt is generally laid to a greater thickness and the binder course gives it greater stability by keying the top more securely to the gravel surface.

While these surfacings have been laid on newly constructed rolled gravel and stone surfaces, the better results have been obtained on surfaces which have been under traffic and maintenance for a considerable length of time.

In Rhode Island, bituminous concrete on gravel has been in service for six or seven years and possibly longer.

Like most of the other New England States, Rhode Island uses a sub-base or foundation course of pit-run gravel under nearly all of its surfacing. This varies in depth from a few inches up to 10 or 12 in.

On this sub-base course a 6-in. rolled gravel surface course is built, which in turn is covered with a 2-in. surface of hot-mix bituminous concrete. This bituminous top is made up largely of local sand and gravel. Two by 4-in. temporary side forms are used during the construction of the top.

The surface regularity is about the same as that of a good penetration macadam.

Average traffic on some of these roads is estimated at between 2,000 and 4,000 vehicles per day, with an estimated maximum of from 8,000 to 10,000.

The roads carrying the heaviest traffic, though still serviceable, show signs of fatigue as indicated by longitudinal, diagonal, and transverse cracks, also a continued depression or wide shallow rut near the edge of the pavement, caused by concentrated traffic.

A thickened edge of bituminous concrete would probably be advantageous.

Greater edge stability of this type of pavement has been secured by making the base course wider than the top course. This has been done on a large contract in California, in Massachusetts, and in other states.

In Michigan asphaltic concrete on gravel base is being built under careful inspection, workmanship, and selection of materials.

They are using a base course extending 6 in. beyond each edge of the surface course, but without the thickened edge.

An extensive test on 12 different types of asphaltic concrete and rock asphalt surfaces on gravel will be conducted in Louisiana. Each test section will be 2,500 ft. long. This test will be watched with much interest and it is fully expected that definite conclusions can be made from the observations and results.

The investigation of low-cost improved roads has not progressed so far that conclusions can be drawn at this time between the relative merits of bituminous surfaces on gravel and on stone bases.

Some localities are getting good service with rock asphalts on gravel and stone base and at a reasonable cost.

Bituminous Macadam.—It is very evident from inspections in New England that this type of surfacing cannot be overlooked.

We must recognize that with good materials and fulfillment of specifications that bituminous macadam has and is still giving excellent service.

Its cost is sometimes higher in parts of New England than bituminous concrete, due to the fact that only the best trap rock is accepted. Results, however, seem to justify this, as we find many miles of bituminous macadam carrying heavy traffic with no more than a normal amount of maintenance cost.

The investigation as conducted so far makes evident the possibilities of classifying between limits the many types, by cost, traffic capacities, soil and climatic conditions, as well as drawing other useful conclusions which will assist the engineer, the producer of materials and equipment, and the contractor in selecting, building, and maintaining low-cost improved roads.

To Classify Fleet Operating Costs

With a view to preparing a uniform basis for keeping the operating costs of fleets of motor vehicles so that the costs of one fleet can be compared item by item with those of another fleet, the accounting subcommittee of the committee on fleet operation and maintenance of the Society of Automotive Engineers has undertaken to collect all available data on the classification of truck, taxicab and motorcoach operation as developed by large operators and various associations. From these data will later be selected all items of operating cost that it is believed should be included in a standard system.

One of the first requisites is thought to be a clear definition of the terms used in the classification and just what items of expense the terms include.

When a uniform classification of cost items has been developed, it is believed that direct comparison of costs can be made by companies operating the same types of vehicle under approximately the same conditions and that by making such comparisons the relatively high items of cost in operation and maintenance of any given fleet can be detected and reduced.

Foundation Engineering and Concrete Road Design

Methods of Subgrade Investigations Described in Paper Presented Before Highway Section, Boston Society of Civil Engineers

By CHARLES TERZAGHI

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For the time being, there are two well-developed methods of handling engineering problems: the method of theoretical analysis, used in bridge design and related fields of structural engineering, and the method of the model test, used in hydraulic engineering. The design of any structure whose integrity is directly dependent upon soil characteristics cannot now and very likely never will be accomplished by analytical methods. On the other hand, the conditions under which soil deposits occur in nature are of such character that they cannot possibly be reproduced in the laboratory with sufficient exactness to warrant the application of the theory of models. Therefore it is quite impossible to apply the methods of the structural or the hydraulic engineer to foundation problems; and when attacking these problems we must have the courage to leave the domain of tradition and to blaze a new trail through unexplored spaces.

If we neglect, for the time being, all possible complications, our problem consists of determining the maximum stresses in an elastic, continuous mat (the road surface) which is to support concentrated loads and which in turn is supported by a homogeneous elastic medium. Thus far theory has failed to furnish even a crudely approximate solution of this problem. Solutions based on the assumption that a change in stress is instantaneously followed by the corresponding change in strain have been attempted. In practice, however, there is a considerable lag in the development of the strains in subgrades, depending on the permeability and the elastic properties of the soil. Hence there is very little hope for a satisfactory solution of the mechanical part of this specific problem. And even though a successful theory of stress distribution in slabs supported by a material with definite elastic properties were eventually formulated, little would be gained, for the reasons which follow.

Topsoil Changes Complex.—The properties of the topsoil, located above the level of seasonal variations in temperature, change from week to week in the most complex manner. The agencies acting within the soil are both chemical and physical in nature, the structure of the soil being the result of chemical changes, dissolving processes, circulation of water, true solutions, colloidal solutions, simple precipitation, flocculation, base exchange, surface tension, and in addition the mechanical activities of living organisms. Every one of these agencies produces within the soil some chemical or physical change. Yet, in their totality, these changes are as reversible as the processes in a living organism. Attempts to compute the over-all mechanical effect of these changes are hopeless. Investigations already carried out for the purpose of throwing light on certain individual phases of the process have involved the most advanced portions of modern physical chemistry. Reports on the results of these investigations form in themselves a whole library. Yet there is not even the shadow of a hope for results of practical applicability. Hence from a theoretical point of view, the highway foundation engineer is in a position similar to that in which the hydraulic engineer finds himself when dealing with the more intricate problems of his profession. The latter, however, taking advantage of the simplicity of the physical properties of water, is able to solve his problems by experiments performed on a small scale; whereas there is no possibility of accurately reproducing natural soil conditions in the laboratory.

Nevertheless, let us assume that in some miraculous fashion we have been provided with an exact method for computing the elastic properties and the drainage properties of the topsoil under extreme climatic conditions. Would such a method, combined with a successful method for computing the stresses in the concrete, solve our problem?

Once more we have to say, No! By stripping the ground, preparing it for road construction purposes, and finally by covering it with a hard road surface, the conditions of life of the soil experiences such a fundamental change that ten years after the road is constructed the properties of the subsoil may have but little in common with those existing when construction starts. So that in spite of the miraculous solution at our disposal, our forecast may be all wrong. In brief, the methods which led to the development of modern bridge design and those invented by the modern hydraulic engineer are both doomed to fail when applied to the problem of road foundations. There is no precedent in the whole field of en-

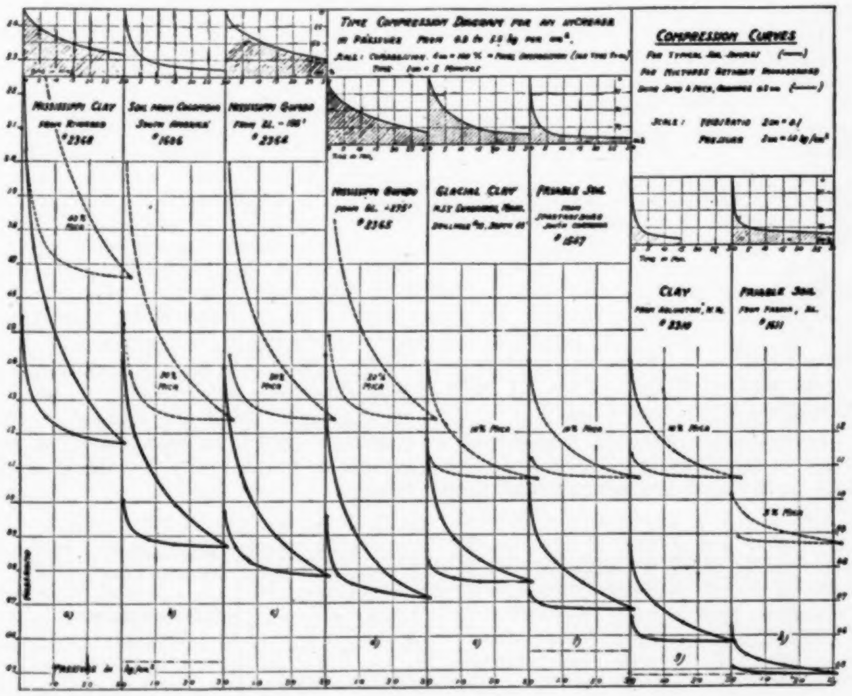


Fig. 1

gineering which can be utilized to advantage in our work. The situation would seem to be quite hopeless were it not for the remarkable success resulting from the application of scientific methods under similar conditions to another field of human endeavor.

Problems in Foundations Compared With Those in Medicine.—Strange as it may seem, this other field is modern medicine. As far as the methods of procedure are concerned, modern road design corresponds to the purely empirical methods of healing, practised until a century or so ago. The advance from the crude empirical methods to modern medicine coincides with the development of modern engineering. But the processes of transformation were quite different in the two cases. There is not a single process in physiology so simple that it can be forced into the narrow framework of mathematical calculation. In addition, there is no means of reproducing artificially the functions of the living organism. Hence in medicine, as in road design, applied mechanics and model testing both fail to produce tangible results. In spite of this, the progress realized during the last century along the line of efficient treatment of diseases was tremendous,—far more important than the 20 per cent increase which we expect in the treatment of poor subgrades. The method which led to success was as follows:

First of all an attempt was made to establish the fundamental principles of the anatomy and the physiology of the normal organism, including a general knowledge of the chemical and physical processes involved in its functions. The next step consisted of a study of the pathological degeneration of the normal organism, with a view to detecting in every case the specific cause which led to this degeneration. The fundamental requirement for the detection of such causes was obviously an exact knowledge of the effect produced on the living tissue by various physical and chemical agents.

The final step was directed towards planning appropriate remedies. In physical respects the evils to be treated were throughout so complicated that no static calculation of stress and strain could possibly be made. Yet the more intimate knowledge of the physical and chemical principles involved led to a whole series of treatments whose effects, as we all know, have been highly beneficial.

Years before anybody thought of a possible relationship between the scientific methods of the surgeon and those of the road construction engineer, the United States Bureau of Public Roads in Washington, D. C., conceived the general plan for a procedure corresponding in every respect to the methods which led medical science to ultimate success.

The knowledge obtained by the modern surgeon in his study of physiology corresponds to the knowledge embodied in the science which we now call Soil Mechanics,—an intimate knowledge of the behavior of soils under stress, of the phenomena of shrinkage,

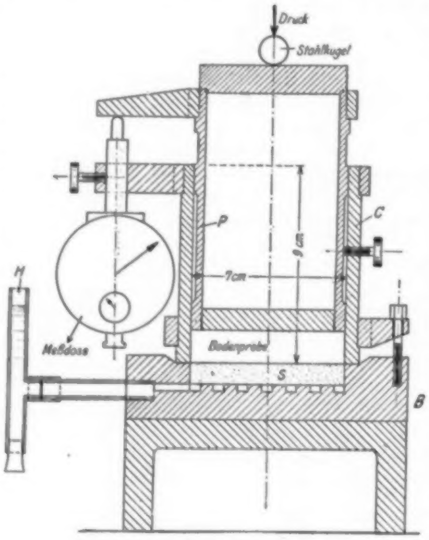


Fig. 2—Standard Clay Container

swelling, volume change due to freezing, flow of water through soils, internal friction and temporary lubrication. The necessity for investigations of this character was emphasized more than twelve years ago by the Foundation Committee of the American Society of Civil Engineers, and activities along related lines are increasing the world over.

The pathology of the surgeon corresponds to the knowledge which should be gained by the results of a condition survey of the roads of the United States. Extensive surveys covering the highway systems of the entire states have been carried on as part of the routine work in Pennsylvania, North Carolina and Washington. An especially extensive survey was made more than seven years ago in California.

The remedies to be used for treating poor subgrades are expected to be derived in part from the results of the condition survey, in part from the observations to be made on experimental roads.

These investigations will certainly not furnish anything which can be compared to a new method of stress computation or to an ingenious short cut in the design of structures. The results will merely consist of a systematic accumulation of facts, of an attempt to retrace the physical causes of the various types of failures, and of a rational study of the results of different types of subgrade improvements. Yet that much, and no more, in the line of systematic experience and insight has caused the transformation of mediæval quackery into modern medicine. If we succeed in improving our methods of subgrade treatment only half as well as the physicians have succeeded in their field, the hopes expressed at the outset of this paper would have to be termed conservative.

The Condition Survey.—The backbone of the proposed action of the United States Bureau of Public Roads is the "condition survey." The success of a condition survey depends on the satisfactory solution of the two following problems:

(a) To get a qualitative conception of the nature of the importance of all the factors on which the state of a road (good condition, partial failure or total failure) may depend. Without previously working out such a conception, the program of the condition survey is apt to be incomplete and inadequate.

(b) To work out a method of expressing facts pertaining to the road and to its condition so as to furnish a maximum of information with a minimum of data. Otherwise the interpretation of the results of the survey becomes a task of discouraging complexity.

Neglecting the effect of the quality of the concrete and the nature of the traffic, the failure of a concrete road is primarily due to volume change of the subgrade. The volume change can be due to a change in water content produced by evaporation, infiltration, or squeezing under external pressure (consolidation due to traffic) or due to expansion of the capillary water as a result of freezing. Under similar external conditions (temperature and humidity) the importance of the volume changes in different soils depends on the differences in type of the soils and in their structure and texture. The effect of freezing seems to be greatly influenced by the percentage of air contained in the voids of the soil, which in turn depends on permeability and drainage conditions. These same factors determine the success or failure of attempts to improve poor subgrades by gravel blankets, French drains and other artificial devices.

The making of a condition survey, therefore, requires the recording of the following data:

(1) Characteristics of the road,—width, type of surface, cross-section including ditches, longitudinal profile of the road and ditches, cut and fill along

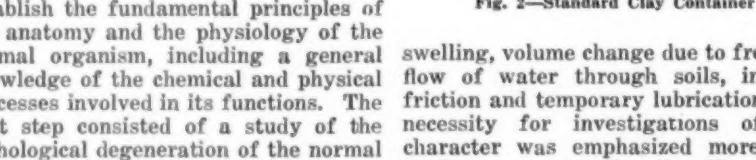


Fig. 3—Hydrostatic Pressure in Water During Process of Compression
Left—Below Perforated, Loaded Piston. Right—In the Voids of a Loaded Permeable Soil

the center line and at the edges.

(2) Condition of the road,—a concise description of the defects of the road surface.

(3) Climatic conditions,—exposure, maximum and minimum temperature, precipitation, etc.

(4) Soil profile and ground-water surface.

(5) Type of soil.

(6) Structure of the soil.

On the basis of previous experience, the United States Bureau of Public Roads has worked out an efficient method for graphically representing the data concerning the design and the condition of roads. For describing the

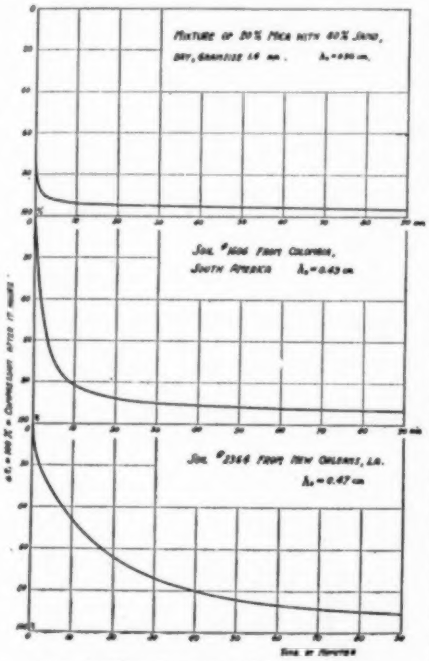


Fig. 4—Time Increase of Compression
Produced by Raising the Pressure from 1.58 to 3.10 Kilograms Per Square Centimeter. h_0= Thickness of Layer at Volume of Voids Zero. 100 Per Cent=Compression After the Pressure Has Acted, 17 Hours

climatic conditions, the methods used by the meteorologists can easily be adopted. Methods for investigating and representing soil profiles have been worked out by the soil experts of agricultural departments, both in the United States and abroad. As a result of their investigations, these experts distinguish different soil horizons, representing the states intermediate between the raw material of the soil, the material located below the limit of seasonal variations, and the topsoil, or the finished product of continuous interaction between the raw material and the atmospheric agencies. It is obviously important to know on which one of these layers the road surface has been established.

Methods of Soil Classification.—The major difficulty in presenting the results of a condition survey is that of adequately describing the soil on which the road rests. The older methods used for this purpose can be divided into two groups: methods based on describing the general appearance of the soils; and methods based on specific soil properties, selected without consideration of their bearing on the behavior of the soil under stress.

The first method consists of an inspection of the soil in the field by a soil expert. The expert opens a shallow pit, examines the consistency by working the soil with his fingers, investigates its structure by scratching it with a tool and records the results of his observations according to certain standard rules. On the basis of the results of a great number of such inspections, the soils of every region are classified according to their characteristics (color, texture, structure), each one of the classes being given a local name. Thus the soil expert speaks of the Iradell clays of the Southeastern States, the Black Waxy of Texas, the Monterello or the Yaguagay clays of Cuba, and hundreds of others, each one of the soil types being confined to a more or less restricted area. The method has been devised for agricultural purposes only. In the domain of agriculture it seems to give, for the time being, more satisfactory results than any other procedure, because the relations between the living plant and the soil are so complex that there is not yet much hope for isolating the manifold chemical and physical factors on which these relations depend. For the simple purposes of the foundation engineer, however, the method is not sufficiently rational. From an engineering point of view it has no advantage over the traditional method of soil classification by expert drill men, based upon visual inspection of the drill samples and on personal experience. It does not furnish any numerical data, and without such data the information is vague.

As an example of the second method, the soil classification proposed several years ago by the Foundation Committee of the American Society of Civil Engineers, may serve. This method is based on physical characteristics, such as the volume of voids, the water content, the mineral composition, etc. However, experience has shown that these data are not sufficient for reliable identification. In this respect the method reminds one of an attempt to base the classification of hydraulic binders on three or four physical properties, selected at random, such as alumina content, fineness and specific gravity. Two binders which have common properties in these respects may be identical or may be very different, according to other circumstances which are beyond the domain of our knowledge.

Simultaneously with the development of the two methods aforementioned, the soil departments of several countries, particularly those of the United States and of Soviet Russia, carried on highly scientific and intricate investigations concerning the colloidal constituents of soils and the interaction between these constituents and dilute solutions, filtering through the soil. These investigations are analogous in their complexity to the more recent attempts to classify the physico-chemical process associated with the settling and hardening of Portland cement. The results of such investigations will undoubtedly broaden our knowledge of the causes of soil behavior. Yet to believe that these studies will ever furnish a suitable basis for a soil classification for engineering purposes is no more justifiable than to believe that the results of physico-chemical investigation of Portland cement will ever replace the classification based on the tensile and compressive strength of cement mortars.

Soil Classification of U. S. Bureau of Public Roads.—In an attempt to

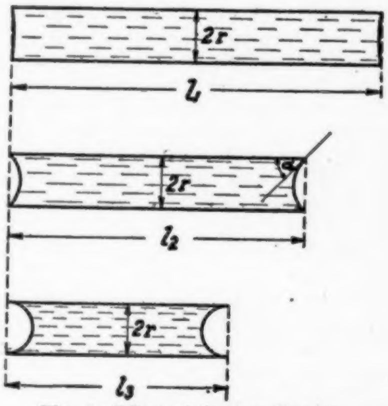


Fig. 5—Effect of Surface Tension
Progressive Compression of an Elastic Capillary Tube Produced by the Surface Tension of the Water, While the Water Evaporates

improve the second method mentioned above, the U. S. Bureau of Public Roads has developed certain soil tests based on soil properties which have at least some relation to those properties on which the behavior of the subgrade depends. These tests are known as the moisture-equivalent, the field-moisture equivalent, the slaking value, the capillary moisture tests, etc. But it was soon found that the relation between the results of these tests and the bearing capacity of the subgrade was not sufficiently well defined to warrant their use as a basis for final soil classification.

The last step made in this direction is a direct determination of those properties on which the interaction between the subgrade and the road surface depends. This step simply means adopting for the classification of subgrades the same method which is used for classifying construction materials according to their behavior under stress, regardless of the physical causes of this behavior. The soil properties which determine the quality of a subgrade are as follows: the amount and the speed of volume change under pressure; the volume change associated with drying and wetting; and the permeability. A general study of these properties has disclosed the following facts:

One of the most conspicuous differences between soils is in the amount

of volume change produced by pressure. If the pressure acting on the surface of a laterally confined layer of soil is raised from 0.4 to 1.5 tons per square foot, the change in the volume of voids may range anywhere between 0.4 and 50 per cent of the volume occupied by the solid constituents. In a similar manner, the elastic expansion produced by reducing the external load from 1.5 to 0.4 tons per square foot may be anywhere between 0.2 and 15 per cent of the volume occupied by the solid. Figure 1 shows the relation between the voids ratio (=ratio between the volume of voids and the volume occupied by the solid constituents) for eight typical soils. According to the results of investigations carried on during the last year at the Massachusetts Institute of Technology, it was found that the compressibility of a soil has very little to do with the grain size. It seems to depend essentially on the ratio between the quantity of rigid, bulky grains and of flexible, scale-like grains present in the soil. The more the bulky grains dominate, the less compressible is the soil. This fact can best be illustrated by comparing the pressure-voids curves of soils with those of sand-mica mixtures with different mica contents. In Fig. 1 the dotted curves represent the compression curves for sand-mica mixtures whose compressibility is similar to that of the soil represented by the curve in the same column. The sand-mica compression tests were made by Mr. Glennon Gilboy in the soil mechanics laboratory of the Massachusetts Institute of Technology at Cambridge, Massachusetts.

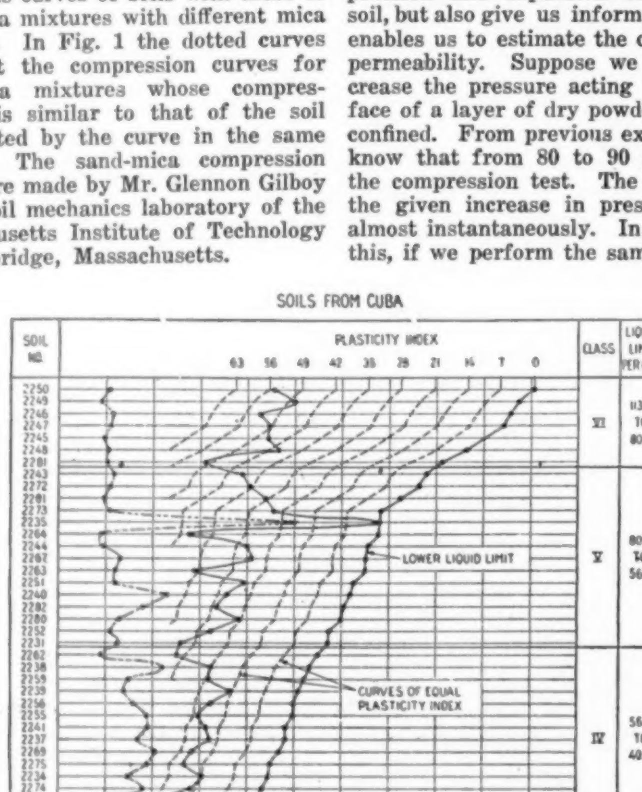


Fig. 6

For obtaining the compression curves of very fine-grained soils, such as clays, silts, etc., the device shown in Fig. 2 is used. It consists of a base B enclosing a porous stone S, a cylinder C, a plunger P, and a lever device for applying pressure to the plunger. The soil sample is located between the base of the plunger P and the top surface of the porous stone S. In its initial state, the water content of the soil corresponds to what is known as the liquid limit; the voids of both the sample and of the porous stone being completely filled with water. Then the pressure acting on the plunger is first raised by increments from zero to 0.4, 0.8, 1.5 and 3.0 kilograms per square centimeter, and then reduced from 3.0 to 1.5, 0.8, 0.4 and zero. Each of these pressures is allowed to act for twenty-four hours. The excess water has a chance to escape or to enter through the porous stone, a layer of filter paper preventing the soil particles from being forced into the voids of the stone.

The results of the compression test performed with this apparatus not only furnish the data for plotting the compression and expansion curve of the soil, but also give us information which enables us to estimate the coefficient of permeability. Suppose we rapidly increase the pressure acting on the surface of a layer of dry powder, laterally confined. From previous experience we know that from 80 to 90 per cent of the compression test. The method for the given increase in pressure occurs almost instantaneously. In contrast to this, if we perform the same test on a layer of clay, whose voids are filled with water, consolidation proceeds from the very beginning at a considerably slower rate. The mechanics of this time lag can be explained by means of a model of the type of Fig. 3. A perforated piston fitting tightly within a cylinder is sustained by two compression springs. If the piston is loaded, it will move downward almost instantaneously into a new position determined by the compressibility of the springs, provided the space beneath the piston were filled with air. On the other hand, if the space beneath the piston were filled with water, the movement of the piston would be very much slower, the speed depending on the number and size of the openings through which the water must escape. From a hydraulic point of view, a soil can be considered as a compressible system of very narrow tubes, and no compression of this system can occur without simultaneously overcoming the resistance of the water while escaping through the tubes. (Fig. 3, right-hand sketch.)

Figure 4 shows three typical consolidation curves. The upper is the consolidation curve of a material whose voids are empty; the two others are curves of clays whose voids are completely filled with water. The difference in shape between the middle and the lower curve is due to difference in the permeability of the two materials. The more permeable material, the steeper is the curve. The equation of the consolidation curve has been derived. Since it contains only one variable quantity, the coefficient of permeability can be computed at once from the time-compression observations which are made in connection with the compression which corresponds to computing the coefficient has been published recently in Public Roads.*

Volume Change Due to Drying and Wetting.—Another soil property of outstanding practical importance is the volume change due to drying (shrinkage) and to wetting (swelling). The mechanics of these two processes can be explained by means of Fig. 5. This figure represents a capillary tube with an imperfectly elastic but very compressible wall. At the outset of one test the tube is supposed to be completely filled with water. If the water starts to evaporate, the surface tension of the water comes into action. The surface of the water at the two ends of the tube, which at the outset was flat, becomes more and more curved, so that the water comes into a state of tensile stress while the wall of the tube is compressed. We can say that the surface tension of the water compresses the tube more and more until finally the surface tension assumes its maximum value. The pressure exerted by the surface tension on the wall of the tube is called the capillary pressure. The tube, still kept under pressure by

*May, 1927, published by U. S. Bureau of Public Roads.

the surface tension, is immersed in water, the surface tension at the ends disappears and the tube expands. Since the tube was supposed to be imperfectly elastic the length of the expanded tube will be smaller than the original length.

A soil sample behaves in the same manner as a system of imperfectly elastic capillary tubes. Hence, from Fig. 5 and from general knowledge of capillary phenomena we can draw the following conclusions: for equally compressible soils, the volume change due to drying increases with decreasing grain size. On the other hand, for materials with equal effective grain size the volume change due to drying is directly proportional to the compressibility.

The shrinkage may be computed from the volume occupied by the soil at the liquid limit and from the volume of the same sample after it has been dried in an oven at 100 deg. C. The shrinkage index, combined with the information furnished by the compression test, gives us a clear conception of the behavior of the material both under external pressure and under the effect of the capillary pressure produced by drying. In their totality, the above-mentioned data define the raw material with about the same degree of accuracy as the character of construction materials is defined by reference to tensile strength, compressive strength and modulus of elasticity. Each of the quantities mentioned has a direct and well-defined bearing on the "action" of the subgrade. There is practically no "personal equation" in the tests, and data will remain valid and useful no matter what the ultimate outcome of the studies of the chemical and colloidal properties of soils may be.

The process of obtaining a complete set of data as outlined above requires about ten days for each set of four or five samples. Considering the large number of samples which should be investigated in order to accurately describe conditions along even a limited section of road, it is evidently impracticable to submit every one of these samples to the tests described above. For this reason efforts have been made to develop simple routine tests which would serve to arrange new samples into groups whose members are practically identical, with the idea of applying the compression test to only one member of each group. The method which has been adopted for this purpose is based on the principle of a procedure worked out some twenty years ago by a Swedish soil expert, A. Atterberg. This principle is as follows:

Let us suppose we mix a soil sample with a quantity of water sufficient to transform the soil into a paste with the consistency of a very viscous liquid. If we let the water evaporate, the material becomes gradually stiffer. It first loses its capacity to flow, and becomes plastic; then it loses its plasticity and becomes brittle, but nevertheless continues to shrink. Finally even the shrinkage ceases. The sample changes in color from dark to light, and at the same time it assumes the properties of a brittle, solid body. We say the soil has passed in succession from the liquid state into the plastic, the semi-solid and finally the solid state. Atterberg suggested describing soils by the water content at which the material passes from one state into the other, and he worked out certain simple standard tests for determining these limits. The position of these limits gives us an approximate conception of the mechanical properties of the marials. In general, the higher the liquid limit, the more compressible the material, the limit ranging between about 20 per cent for sandy, very feebly compressible materials, and more than 100 per cent for highly compressible soils. The difference between liquid and plastic limit is called the plasticity index. For materials with the same liquid limit, the plasticity index gives us some information about the permeability, because in general the plasticity index increases with decreasing permeability.

Figure 6, representing the limits for various soils from Cuba, may serve as an example of the possible variation in the character of soils as expressed by Atterberg's limits. The limits in themselves are not a sufficiently reliable indication of the behavior of the soil under stress. Yet from experience we know that two soils coming from the same locality are practically identical, provided their limits are practically identical. Hence for a preliminary comparison of soils the method serves its purpose.

According to Atterberg's procedure, the determination of the limits was made by hand with very primitive means. As a consequence it was difficult, if not impossible, to get consistent results from tests performed on the same soil by experimenters working in two different localities. In order to exclude this "personal equation," attempts are being made to perform the necessary operation by means of mechanical devices. At present the experiment station of the Bureau of Public Roads in Arlington, Va., is performing compression tests, including time-compression observations on about 40 representatives of the family of soils shown in Fig. 6. The results of these tests will, for the first time, furnish material sufficient for a broader interpretation of the meaning of Atterberg's limits. Special investigations concerning testing methods and soil classification are carried on in the soil testing laboratory of the Massachusetts Institute of Technology under a cooperative arrangement with the United States Bureau of Public Roads.

Soil Structure.—Thus far the results obtained by means of the newly developed soil tests are very encouraging. Yet there is one thing no method of testing soils in a laboratory can possibly achieve, and that is to reproduce the original structure of the soils. For plain foundation work on soils located below the lower limit of seasonal variations in temperature and in humidity, this fact is without consequence, because we are in a position to withdraw from the ground samples in an undisturbed condition and to express the original structure by a single figure—the consistency factor. In contrast to the deeper layers the structure of the top soil cannot possibly be expressed by a single figure, because it is apt to change from week to week, and, further, because it is the result not only of mechanical action, but also of biological and chemical activity. The soil tests performed in the laboratory merely furnish information about the raw material of which the top soil consists.

Since no attempt is made to compute the actual stresses in concrete road surfaces, the failure of the method to yield definite information concerning the actual structure of the soil is not especially serious, for the following reason: No two roads can be compared with each other unless they have to withstand the same traffic under fairly similar climatic conditions. Under similar climatic conditions identical raw material develop into similar soils with a similar structure. Hence if we know that two raw soil materials are similar, we may conclude that the two top soils formed therefrom under similar climatic conditions are almost identical. The extent to which this identity exists must be determined by experience.

This type of consideration is a characteristic procedure when dealing with the more intricate problems of soil mechanics. We are only searching for a reliable basis for comparison. This basis once established, operations are carried out in a strictly empirical manner, our scientific knowledge being used merely to assist in the interpretation of observed facts, and not for the purpose of computation.

Conclusions.—The attempt of the United States Bureau of Public Roads to establish a basis for the design of concrete roads by means of a condition survey undoubtedly represents one of the prominent landmarks in the field of civil engineering. To lead the enterprise to final success requires methods of procedure which are as fundamentally new as the methods recently developed in the hydraulic laboratories of Europe for solving the problems of river improvement and of hydro-electric power development. As far as their essentials are concerned their methods resemble those which have been successfully used in medicine much more closely than those which are customary in engineering. Putting these methods into practice therefore requires a thorough mental readjustment on the part of engineers engaged in the enterprise.

The reason for the striking contrast

between the high state of perfection of the semi-empirical methods of medicine and the rudimentary state of the same methods applied to foundation engineering is essentially psychological. The rapid development of modern engineering was due to obtaining accurate solutions of various problems by means of applied mechanics. As a consequence, theoretical treatment of engineering problems looked to be so promising and so attractive that almost all the productive brain power available was focused on applied mechanics; those problems which could not be approached from a theoretical standpoint were simply neglected. The result was that some branches of engineering were developed to the very limit of prfection, while othrs remained in a deplorably backward state. In mediicne and in physiology there are no problems simple enough to be treated by means of applied mechanics; semi-empirical methods are the only ones which are apt to give results. Hence, from the very beginning, the men engaged in these fields had to choose between remaining on the general level of ignorance or developing methods for gradually approaching the truth by systematically reducing the importance of possible error. The remarkable success achieved in medicine and physiology is the best guarantee we have for ultimate success of semi-empirical methods in foundation engineering.

State Aid Road Work in Pennsylvania.—Governor Fisher has approved the Hess bill appropriating $8,500,000 from the state motor license funds for state-aid road construction of county and township roads and for streets of Philadelphia. The sum of $500,000 is appropriated to counties of the first class for road construction and maintenance. Philadelphia county, the only first calss county in the state, is coextensive with the city of Philadelphia. This is the first appropriation to that county for road work since 1915.

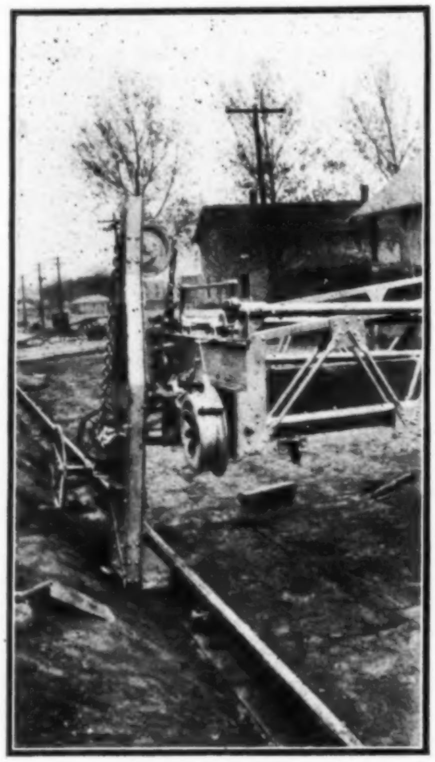
The governor allowed $3,000,000 for township rewards, cutting $1,000,000 from the amount appropriated by the legislature, and $5,000,000 for state-aid work in counties. These two latter amounts are the same as were allowed two years ago.

$50,000,000 Road Program Proposed in Persia.—The Director General of Roads has submitted to the Persian government a program for a system of highways totaling 10,576 miles to be built over a period of nine years at an estimated cost of $52,305,000.

Spain to Spend $72,150,000 on Roads.—Spanish Royal decree authorizes expenditure of 409,000,000 Pesetas ($72,150,000) for the resurfacing of macadamized highway in Spain.

New Jack for Finishing Machine

A special jack for mounting the transportation wheels on finishing machines has been developed by The Lakewood Engineering Co. of Cleveland, O.,



Jack for Mounting Wheels on Finishing Machines

manufacturers of Lakewood screens and tampers.

This jack enables the contractor to quickly and easily remove or install the transportation wheels on the job. The illustration shows how the finisher is raised and lowered.

Speed Limits on Highways

With Iowa soon to set a speed limit of 40 miles per hour and many states contemplating the passage of laws providing a minimum speed on the public highways of anywhere from 15 to 25 miles per hour, it is interesting to recall that in 1901, New York passed its first speed law which limited the speed of motor vehicles to eight miles per hour in built up sections and 15 miles per hour in open country.

No state now has such low restrictions. According to the Service Bulletin of the Iowa State Highway Commission the probable present average for the United States is at least 30 miles per hour in open country. Some few states place it at 45 miles per hour and some have no restrictions. In 1925, ten states made changes in their speed laws and in every case the maximum was materially increased.

New Architect's, Surveyor's and Builder's Scale

Although professional construction surveying has hardly begun its infancy in this country, yet it has already brought about the development of a new scale as a result of the efficient methods used by the surveyor in the measurement of drawings. This new scale greatly increases the speed and accuracy of the Architect's drawing, the Surveyor's measurement and the Builder's interpretation of the drawings in the process of erecting a structure, because it is a positive scale and therefore there is no loss of time or accuracy due to approximating.

This new scale, is an architect's, surveyor's and builder's chain scale. It consists of four beveled edges with two scales on each side, starting from left to right on opposite edges making the scale readable without turning it end for end. The two scales on one side are divided as ¼ in. representing one foot and each foot sub-divided into 12 equal parts to represent inches. Numerals are shown at each foot represented on the scale and the same divisioning continues from end to end. The two scales on the reverse side are divided as ⅛ in. representing 1 ft. with 1 in. sub-divisions. The numerals on this side of the scale are shown at each 2 ft. representation of the scale. These scales are accurately engine divided upon white celluloid, mounted on good quality seasoned wood stock and manufactured similar to the highest grade scales now on the market.

These chain scales may be made in any reasonable length, although it has been found from practical experience that 6 in., 12 in. and 18 in. length scales are most convenient to use, depending, of course, on the size of section to be measured. The 12 in. length scale indicating 48 ft. on 2 bevels and 96 ft. on the other 2 bevels has been experienced as the most efficient and practical length scale for general use by the architect, construction surveyor and builder. Three-inch sub-divisions instead of one-inch subdivisions may be obtained when desired.

The above description of design applies to the chain scales of any other graduations, wherever the inch unit of masure is divided into equal parts to represent feet and sub-divided to represent fractions of the one foot divisions.

These scales may be secured from the Universal Engineering Co., Bridgeport, Conn.

Insures 500 Miles of Road.—The Commissioners of Upper Darby Township, Pennsylvania, have awarded a contract for highway insurance. The township, under the insurance terms, is protected in the sum of $630,000 against claims for accidents on the 500 miles of highways in the township.

A Highway Motor Transport Survey

Its Purpose, Organization and How It Is Made Described in Paper Presented April 21 Before Graduate Engineering Society at University of Michigan

By E. E. POWELL

Traffic Manager Black & Decker Manufacturing Co.; Formerly Traffic Engineer, U. S. Bureau of Public Roads in Chicago of Cook County, Illinois, Survey

The urgent need for more and better highways, as a result of the recent and unprecedented increase in the number and use of motor vehicles, is an established fact. Because of the vast amount of money involved in the construction of new highways and in the maintenance of old highways and because the available funds cannot keep abreast of the actual needs, the planning of highway systems has become more than a problem of engineering and administration.

It is now essential that highway executives acquaint themselves with those economic factors which affect the utilization of their highways before they can enter upon a wise and economic program of road building. They must know the amount and type of present traffic and the probable future traffic over highway routes.

Various methods for obtaining estimates of the amount of traffic passing over a highway system or any of its component parts have been employed by states and counties. The most common method has been by means of a census of vehicles at regular intervals on selected highways. The first traffic count, so far as is known, was made on a section of the Lincoln Highway in Pennsylvania, in 1830, where the number of broad and narrow wheel wagons, carriages, one and two-horse wagons, gigs, carts, riding horses, and cattle were recorded. The counting of vehicles, since the rise of the motor vehicle as an important part of our transportation system has been resumed in the past few years as a necessity.

A count of vehicles, however, does not disclose all the important facts necessary in economic highway planning. The use of some highways by motor truck freight lines and heavy units of transportation makes the tonnage of traffic as important a factor as the number of vehicles. And so, in order to obtain reliable traffic information the traffic count, or census, has been extended to include the recording of vehicle weights and additional data. This new, intensive method of traffic analysis has been termed "Highway Transport Survey."

The highway transport survey was created and fostered by the United States Bureau of Public Roads, which has, up to the present time, co-operated with seven states and one county in carrying on transport surveys.

Purposes of a Highway Motor Transport Survey.—In addition to the general purpose of the survey, discussed above, there are specific purposes which can be outlined as follows:

1. To make possible the adaptation of highway design to the volume and type of traffic by determining:
   (a) Passenger car and motor truck density on various roads;
   (b) Tonnage passing over highways and between points of origin and destination;
   (c) Predominating types of vehicles (whether passenger cars, passenger busses, or motor trucks);
   (d) Motor truck capacities, types of tires, body types, body widths, and
   (e) Motor truck net, gross, and wheel loads.
2. To aid in the proper apportioning of construction and maintenance funds over the highway system by determining:
   (a) Amount and volume of traffic, and
   (b) Seasonal variation in traffic.
3. To obtain reliable information for the regulation of traffic by determining:
   (a) The percentage of motor truck net loads in excess of the rated motor truck capacity;
   (b) Percentage of motor truck loads in excess of the legal maximum gross weight;
   (c) Percentage of motor truck loads in excess of the legal maximum gross weight per inch of tire width, and
   (d) Width of motor truck bodies and their relation of overloading.
4. To estimate the relation between motor transport and other methods of transportation by determining:
   (a) The types and net tonnage of commodities hauled by motor trucks;
   (b) Length of motor truck hauls;
   (c) Types of motor truck freight shipments, and
   (d) Crating and packing of commodities transported by trucks.
5. To obtain general traffic information for the prediction of future traffic.
6. To serve as an aid in approximating the service values of various highways by finding out:
   (a) Volume and kind of traffic, and
   (b) Cost to own and maintain highways.

Field Organization.—The first step in the organization of a highway transport survey is a preliminary reconnaisance of the area in which traffic is to be examined. The area usually selected is a political division, generally a state or county. The industries in the area, the population of its cities and towns, and other economic factors which affect traffic are given careful consideration in the choice of highways to be included in the survey.

The preliminary reconnaisance is followed by a general field organization which can be outlined as follows:

1. Choice of survey stations, points at which vehicles are counted and information recorded.
   (a) Separation of these stations into "weight" and "recording" groups;
   (b) Locating of stations on suitable stretches of roadway;
   (c) Grouping of stations into party sections, and
   (d) Division of the area into "districts."
2. Formulation of schedules for operation.
   (a) Number of times each station is to be operated during the course of the survey;
   (b) Methods for avoiding a duplicate count of traffic;
   (c) Choice of days of the week on which stations are to be operated, and
   (d) Hours of operation.
3. Personnel.
   (a) Field manager;
   (b) Assistant field manager;
   (c) Clerks for routine work in the field office;
   (d) Supervisors, one to be assigned to each district;
   (e) Chiefs of parties;
   (f) Recorders and weighers to be assigned to parties;
   (g) Party organization, and
   (h) Instructions for field men.
4. Equipment.
   (a) Purchase of;
   (b) Distribution, and
   (c) Maintenance.

Stations.—It is necessary to decide upon points, on the selected highways, at which vehicles are to be counted and traffic information recorded. Because of the prohibitive cost of maintaining stations at regular intervals along the road, it is only possible to have stations at certain selected points. Upon the length of the highway, the distance between towns and cities, and the importance of the highway (a primary, secondary, or third class route) depends the selection of survey stations.

The stations are divided into "weight" and "recording" groups. At weight stations all trucks are weighed upon

portable or platform scales, all vehicles counted and recorded at the end of each hour, and traffic information recorded. The information recorded, in the case of motor trucks includes:

1. State of license;
2. Make and capacity;
3. Body type and width;
4. Towns or cities of original and destination;
5. Type of origin and destination (farm, railroad terminal, etc.);
6. Type, packing, and value of commodity hauled, and
7. Tire types and dimensions.

Passenger car information recorded includes:

1. State of license;
2. Make and capacity;
3. Number of passengers;
4. Situs of ownership (whether city or farm);
5. Type of utilization (whether for business or pleasure), and
6. Towns or cities of origin and destination.

There is, in addition, certain specific traffic information which varies in different states and counties.

At recording stations the same information is recorded as at weight stations with the exception of weights. It is impossible to erect platform scales or to provide portable scales for use at all traffic survey stations.

For the convenience of recording the data secured, each station is given a number. Serial numbers are devised so that weight and recording stations can be readily distinguished and the district in which they are located, determined. Each field party has a serial number which is also a part of the survey station number.

The location of each station must be at a point along the roadway where there is a straight and level stretch to eliminate any possibility of accident and also to enable trucks and passenger cars to be stopped and started with ease. It is not always possible to do this, especially at cross-roads or in a hilly area. Utmost care and courtesy must be exercised at all times by field personnel to insure ease and success in operation.

Party sections are formed by assigning to each party a certain number of stations in a certain locality, the number of stations to be operated by each party having been previously determined. The selection of stations for each party is made so that the distance of travel between stations is reduced to a minimum. This is very important, especially in the case of parties which operate a different station every day.

Districts are usually composed of one or more weight party sections and two or more recording party sections. The boundaries of a district are determined by the boundaries of the party sections assigned to it. The number of districts in a state depends upon the size of territory which can be adequately handled by a district supervisor in the proper supervision of his parties. Wherever possible all districts should have approximately the same number of party sections and cover areas of approximately equal size.

Schedules.—Schedules of operation for each party are prepared by showing the date and hours at which the parties must operate the stations in their sections. These schedules are divided into cycles, each cycle covering the full number of stations to be operated. The schedule is so prepared that each station will be operated on a different day of the week every time it is operated in order to secure an operation at each station on each day of the week.

Schedules of the various parties must be arranged so as to eliminate any possibility of a duplication of traffic, that is, two or more parties cannot work in close proximity to each other lest they record the same data for the same trucks or passenger cars on the same day.

The hours of operation are usually for a 10-hour period, from 6 a. m. to 4 p. m. during one cycle, and from 10 a. m. to 8 p. m. on the next cycle. There are night parties which operate selected stations from 8 p. m. to 6 a. m. Weight parties usually operate six days a week with Sundays off, while recording and night parties operate seven days taking the eighth day off.

Personnel.—The field manager has full charge of all field work connected with the survey. His duties are to see that the district supervisors perform their duties in an efficient manner, to visit the various districts regularly and make such changes in personnel as he may deem advisable for the benefit of the parties concerned and the survey in general.

The field manager must have an assistant whose duties are to attend to the office routine and to keep in constant touch with the district supervisors and parties by means of daily reports. He audits all expense accounts and furnishes the field manager with any information relative to mismanagement by district supervisors or laxity on the part of party chiefs to follow their instructions. He should be assisted by a sufficient number of clerks to adequately handle the office routine.

Each district supervisor is in direct charge of the personnel and operation in his district and is held strictly responsible for all operations in his district. It is the duty of the district supervisor to inspect his parties regularly and examine the records secured by each party, making such criticisms and changes as he sees necessary; to assist the party chiefs in keeping the morale of the parties to the highest point of efficiency; and to transmit all orders emanating from headquarters to his parties so that they can be properly followed.

Each party chief is in direct charge of the recorders assigned to his party. He has to see that they perform the duties assigned to them by him and that they carry out instructions issued by the district supervisor and field manager. He is responsible for all equipment and supplies issued to him, and for the maintaining of a high degree of morale in his party.

In the organization of a party it is well for the party chief to assign to each member of the party specific duties, the party chief taking a certain portion of the work himself, preferably duties which will enable him to keep a constant check on the efficiency of the men in the party in addition to his own duties. Weight parties consist of from three to ten men in addition to the party chief, the number of men depending on the density of traffic to be handled at the various stations which they operate. Recording parties usually have from one to two men in addition to the party chief. Night parties usually have two men, including the party chief; in some instances, however, the work can be done by one man provided the density of vehicles at the various stations is not too great.

All instructions regarding the operation of the survey should emanate from the field manager to the district supervisors, to the party chiefs, and thence to the men of the various parties. Each man on the survey, from district supervisor to recorders, must be equipped with a full set of instructions concerning the operation of the particular party or district to which he is assigned. These are absolutely necessary so that each man can study his instructions individually and secure a thorough knowledge of the work that he is called upon to perform.

Equipment.—In the distribution of equipment it is first necessary to make up a standard list of material needed by each type of party. The field manager and division supervisors must be equipped with automobiles, together with other small equipment necessary for the proper performance of their duties.

The weight parties are usually equipped with motor trucks, portable scales, road banners, lanterns, tables, chairs, field desks and other small items of equipment necessary for the proper performance of their duties. Light delivery trucks are necessary for weight parties due to the fact that they have to carry a number of portable scales which are rather heavy and cannot be handled to advantage in a touring car. Recording parties are equipped with touring cars and the standard equipment used by weight parties, with the exception of scales.

In order to properly care for the equipment in the field it is sometimes necessary to have a mechanical inspector to inspect each car, truck, and scale at frequent intervals, making a

report to headquarters after each inspection. Division supervisors and party chiefs are held responsible for the care of the equipment issued to them; the improper use of it is sufficient cause for immediate dismissal.

Headquarters Organization. — All traffic information recorded in the field is transmitted to the headquarters office. Here the data is checked, classified, analyzed, and prepared for presentation in printed form.

After field records have been checked, each item is given a code number which is subsequently punched on tabulating machine cards. These cards are sorted by electric machines into proper groups and then run through tabulating machines which add and print the information desired.

The personnel of the headquarters office consists of the executive in charge of the entire survey or surveys, his assistants, statisticians, clerks (administrative, statistical, and coding), and punching and tabulating machine operators.

Duration of a Transport Survey.— The size of the survey territory, the number of stations, and the number of operations at each station determine, to a large extent the duration of the survey. It is generally conceded that an intensive survey must last at least four months. Since traffic varies considerably at different seasons in a year, it is advisable to continue a fundamental survey for a year period. However, by operating during the summer and again during the winter season it is possible to arrive at fairly accurate estimates of traffic during the remainder of a year.

Tourists Net State 90 Millions in 1926

Foreign car tourist traffic in Wisconsin for 1926 shows an increase of 11½ percent over 1925, according to quarterly progress report of the State Highway Commission.

It is estimated in the report that approximately 3,000,000 automobile tourists from other states visited Wisconsin during the 1925 tourist season and that they left $90,000,000 in the State.

Highway traffic in general, as shown by an eight-day count at seventy-one points on the state highway system in 1926, shows an increase of 5¼ percent over traffic in 1925.

Road Marking in Wisconsin.—Approximately 2,200 miles of state trunk highway were marked and signed in 1926, according to the quarterly progress report of the State Highway Commission of Wisconsin. These roads now have the new type of direction marker which is a sign with a black border and with black lettering on a white background. They have also the caution and warning signs which have a black border and black lettering on federal yellow background.

Engineering Representation In Contracting

Its Value Discussed in Paper Presented at Convention of American Road Builders' Association

By W. M. WILLMORE,
Secretary-Treasurer, Wabash Construction Co., Vincennes, Ind.

This is a subject that seems to admit of considerable, as well as a sharply divided range of opinion.

As a result of thorough inquiry among a number of good contractors I find them divided into two primary groups. Those who feel the engineer a valuable asset to the contractors' organization and those who take the opposite view.

These two classes I find are further divided! 'The contractors who are themselves engineers, I find on both sides of the question; and likewise contractors, who like myself, have had no training in that line, also differ in about the same manner.

Favors Engineers in Contracting Organization.—My decision in favor of the engineer in the organization was the result of finding myself, on different occasions, confronted with a question or proposition concerning which I could not satisfy myself as to the proper solution or procedure and for assistance in determining these matters I had the help of good superintendents who, though more practical than I in the construction work, had no more knowledge of engineering propositions than myself.

From personal observation and experience, however, and also from careful inquiry among many of the best contractors in my line I find the class of contractors favorable to the use of the engineer seem to agree that: Unless you make use of an engineer who has also had practical experience as a contractor or who has had experience in a contractor's organization other than engineering duties exclusively the contractor is not likely to find such engineer much of an asset to his organization.

Co-operation.—We all desire the co-operation of the engineering personnel of the political subdivision under whose jurisdiction the contractor is doing his work and more particularly the project and resident engineers on state work. The engineer in the contractor's organization can well be the means to that end, if he be competent and tactful.

Not infrequently the project engineer is pressed for time in looking after the many engineering details on his project and if a spirit of co-operation has been cultivated by the contractor's engineer, he can be of considerable assistance to the project engineer, thereby enhancing somewhat the position of the contractor and in nowise impairing the efficiency of the engineer, or engineers on the job. A check up on stakes and other engineering details, by the contractor's engineer avoids errors, and not infrequently, unnecessary work, and through the proper co-operation his assistance to the engineer in charge will very often aid the contractor in the prompt prosecution of his work by seeing to it that all engineering details are considerably ahead of the operations on the job.

Contractor's Engineer Can Be of Great Assistance.—Contingent upon the extent of competency of the contractor's engineer, he can be of material help to the superintendent of construction and can more particularly co-ordinate, or at least study the co-ordination of the operations on the job in the interest of greater efficiency in the organization as a whole.

We all know if our construction problems could be talked over with the chief engineer or general superintendent of construction of the various highway departments our troubles would generally be easily handled or corrected, but this cannot be done at all times, and seldom ever on the job, consequently, he must be represented on the job by a "resident engineer," a "project or district engineer" or an "inspector," as the case may be, and from two to three times removed (in the matter of authority) from the chief engineer or general superintendent.

Inexperienced Highway Engineers.— Experience has shown that the class of engineers furnished on the job, as a general matter, are young, inexperienced and lacking much or most of the practical side of their profession and consequently, as a matter of course, are all the more given to the one side of their work in which they have had experience, namely, the "theoretical" or "technical" and many times the impractical.

This condition comes as a result that most of this class of engineers are either fresh or not more than a year or so from college, and while nothing in the preceding paragraph or in this paper is meant to convey the least reflection on the young or new engineer fresh from school, rather it is intended to show that a diploma from college, instead of completing their schooling means they are now well equipped to begin that schooling furnished only in one university of the world, The School of Experience, and as a matter of course we are that school, to them, to a greater or less degree.

We continue largely to be that school, for owing to the fact that government and state appointments as a class, pay very modest salaries, they do not attract to their organizations men of mature years and experience to a very large degree, consequently, a few years of experience with the road builders for this young engineer and he graduates from our school and is off to better and more attractive pay in other lines,

hence, as above stated, we continue largely to be that "School of Experience" for more to follow.

I find this statement well supported in several replies received from contractors of whom I have made inquiry for suggestions on the subject matter of this paper. Quite a few, in relating their experience with an engineer in their organizations, have made mention of the fact that the engineer or engineers alluded to were formerly in the employ of state highway departments.

Competent Engineer Valuable Asset.—Then again if it is not the case of the young, inexperienced engineer, as just described, it may be an engineer of years of experience in addition to the necessary technical training but must be satisfied with the small salary usually paid in such cases. And what does that generally mean? Either that he is of only ordinary ability, not altogether competent, or may be a failure altogether for anything in his line that offers better pay than state road and bridge work, and this condition cannot inspire the confidence and satisfaction with the contractor he would be expected to have in that particular part of his work.

An engineer in the contractor's organization, of the sort mentioned in the first part of this paper, one who has had sufficient technical training to be classed an engineer, and also with sufficient practical experience to be able to tell when the technical should leave off and the practical begin, and with ability to direct others in that branch of the work, is in my opinion a valuable asset to the contractor's organization.

By tying in, as it were, with the young, inexperienced engineer heretofore mentioned, he can soon convince the young man that he is there to work with and not against him. This will inspire confidence and respect and naturally avoid what would otherwise often be bad mistakes and costly misunderstandings.

Contact with State Highway Engineers.—Your own engineer on the job is the only man to check the work of the state engineer and likewise the one best calculated to call to his attention errors or mistakes and work out with him a mutually satisfactory correction or necessary change of plans.

How often has it happened with you, a mistake in rough grade stakes, not discovered until the fine grade gang came upon it and as a result your paver lost a day, or a good part of a day, while the error was being corrected? Your own engineer, by checking the engineer in charge, could have caused this correction to have been made far in advance of the paver and have prevented this costly loss of time. A few experiences of this kind during the construction season will cost you more than the time of your own engineer.

Often the paving contractor takes a job where the dirt work is heavy to the point it is advisable or even necessary to sublet the earth work. This is generally done with the proviso that rough grade must be within 2/10 ft. of finished grade. What can be more necessary or mutually satisfactory to you and the grade contractor than your own engineer on the job to see that this provision of your grade contract is complied with?

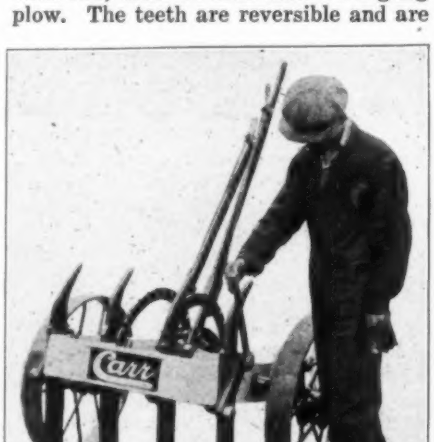
The services of the contractor's engineer can be made invaluable in the final cross-sectioning of the road, and in the payment of final estimates.

The state engineer on the job is alone as it were. He has problems to work out that to him are just as serious as any of your own. Unless he is a very peculiar individual indeed, he will at times yearn for and welcome the advice, suggestions and assurance that can be furnished by your engineer.

Will not this be conducive to better feeling and understanding than might sometimes otherwise exist, and will not this condition on the job result in that co-operation and co-ordination so necessary to good results?

New Road Rooter Has Many Uses

A new device, called the Road Rooter, can be used with one rooter, or tooth, just as a rooter plow with wheels instead of plow handles, or it can be used with two, three or four teeth as a gang plow. The teeth are reversible and are



The Road Rooter

held in place by the old, but reliable, U bolt clamp. In this case the U bolts are equipped with cold finished nuts and a box wrench is furnished to make for ease in the frequent loosening and tightening necessary in moving the teeth.

As this tool has to keep pace with modern tractors the wheels have been equipped with Timken bearings. The solid steel frame is electrically arc welded. The Road Rooter is manufactured by Ted Carr & Co., 939 North Ave., Chicago.

Time Clause in State Highway Contract

The new highway contract of the State Highway Commission of Maine contains the following "Time Charge" clause:

"Time is an essential element in this contract. As the prosecution of the work will incommode the public, obstruct traffic, and interfere with business, it is important that the work be pressed rigorously to completion. Also the cost to the Commission of the administration of the contract, including inspection, engineering, and supervision, will be increased or decreased as the time occupied in the work is lengthened or shortened. Therefore a time charge of....................Dollars ($............) per day (exclusive of Sundays and State of Maine legal holidays) will be made against the Contractor and the amount of it will be deducted from the contract price as payments are made. This charge will be commenced on the date on which work is to begin as stated in the Engineer's notice to the Contractor to proceed with the work and will continue to the completion of the work. Each Bidder should include in his estimate of the work a sum equal to the amount derived by multiplying said time charge by the number of days within which he estimates he can complete the work. The time charge will be suspended during the period of any delay that may be caused by the Commission, either through changes in plans, or through ordering suspension of work for any reason."

Joseph W. Hunter Passes On

Joseph W. Hunter, of Jenkintown, Pa., and first State Highway Commissioner of the state of Pennsylvania, died on May 19 at the age of 73. A prominent highway engineer, Mr. Hunter started as a surveyor with Samuel L. Smedley, of Philadelphia, in 1870, his first work being a topographical survey of that city. In 1875 he moved to Jenkintown and entered business there as a topographical engineer and farm surveyor. He was elected County Surveyor in 1882. In 1903 he was appointed Highway Commissioner and served in that capacity until 1911, when he was made advisory township engineer for the State Highway Department. At the time of his death he was slated for appointment as Deputy Secretary of Highways. Mr. Hunter was a member of the Engineers Club of Philadelphia, the American Society for Testing Materials, the American Road Builders Association, and other organizations.

New York City Has 4,000 Motor Vehicles.—The city of New York now maintains a motor fleet numbering over 4,000 vehicles. This represents an increase of about 3,500 vehicles in the last 10 years.

Bituminous Types of Pavement for Streets and Roads

An Interesting General Discussion of a Subject Given in a Paper Presented at Thirteenth Annual Road School at Purdue University

By H. W. SKIDMORE,
Consulting Engineer, Chicago Paving Laboratory, Inc., Chicago, Ill.

Bituminous pavements are naturally divided into two distinct groups by reason of basic difference in methods of construction. One is the penetration type in which the bituminous binder is applied externally (either hot or cold) and penetrates the structure by gravity; the other is the pre-mixed type in which aggregates and binder are mixed together in given proportions (also either hot or cold) before they are applied. There are numerous variations of these two fundamental types and modifications as to composition enable both to be used as foundation and wearing surface. In discussing the broad, general subject of bituminous pavements it would seem logical to proceed from the most simple form of construction to the most complex.

Surface Treatment.—In a strict sense bituminous surface treatment of various kinds of road surfacings should not be classified as a bituminous pavement, but since bituminous binders are so employed, some discussion of the subject is proper.

Surface treatment may be applied to a number of different types of roads and pavements, such as earth, gravel, stone, macadam (both water-bound and bituminous), brick and block pavements as well as the asphaltic types. It is intended to do just what the name indicates—place the surface of a given roadway in better condition for carrying the traffic. It is not permanent, but must be repeated from time to time, depending upon the nature of the pavement structure treated and the intensity of traffic.

The nature of the bituminous material used for the surface treatment may vary from extremely liquid form, such as a road oil which may be applied cold, to a solid material which may be applied either hot or preferably cut-back with a light solvent or volatile distillate. For treatment of gravel or stone roads the cut-back material is particularly advantageous and most excellent results can be obtained, as witness the work which has been recently carried on by the Indiana State Highway Department.

Surface treatment of old brick and block pavements is frequently employed to waterproof and smooth up the surface. The usual procedure is to apply the bituminous binder (which may be either cut-back, emulsified or applied hot) to the dry, clean surface of the pavement in a film of uniform thickness. This is best accomplished by means of a pressure distributor. As soon as the material is applied it is covered with a thin layer of stone chips or coarse sand. Usually a second coating of binder is applied, followed by a second layer of chips, etc. An appreciable depth of mat is developed in this manner and may serve for a considerable period of time, depending upon the intensity of the traffic. In applying asphalt hot, it is important that the surface of the old pavement be very dry and clean and that the temperature of the material be 300 to 325° F. when applied. By the same procedure old hot-mix asphaltic types of surface, which have become dry due to their age, can be revived and rehabilitated. Before treating the surface of an old pavement, depressions should be corrected by suitable means, such as cold-patch, penetration, etc.

Bituminous Macadam. — Bituminous macadam surfaces are usually laid upon crushed stone or gravel foundation; however, they are not necessarily confined to this character of base, but are frequently laid upon portland cement concrete or black base of either the pre-mixed or penetration type.

Black Base (penetration type).—This type of foundation is adapted to and commonly used for a variety of surfacings, such as brick, block, asphaltic concrete, sheet asphalt and penetration macadam. It is constructed according to the general procedure applicable to bituminous macadam surfaces. The distinguishing differences consist of the absence of a seal-coat and top dressing and the use of larger stone in the base course. The size of the aggregate will depend upon the total thickness of base required or the thickness of the respective layers constituting the foundation structure. For example, if a 4 in. base is to be built, or a thicker base composed of 4-in. layers, the coarse aggregate should pass a 3½-in. ring and be held on a 2½-in. ring. If the base is built in one course, keystone or "choker-stone" is applied in the usual way after the coarse aggregate has been laid and rolled; whereupon is applied the binder, hot or cold. From 2 to 2½ gal. per sq. yd. will be required.

Softer aggregates than are required in the surface may be used in the base, although this does not mean that wholly inferior materials, such as will crush in rolling, should be used. Material which will crush as nearly cubical as possible is preferable in all kinds of macadam and penetration work.

Penetration Top Course.—Bituminous macadam surfacing or penetration top course usually varies in thickness from 2 to 3 in., most often 2½ in. For 2½-in. topping, 2-in. to 1¼-in. stone may be used for the coarser aggregate. If the wearing course is to be laid upon black base or broken stone, somewhat greater maximum size may be used because of the keying of top stone into the base. On any type of rigid base it is obvious that such a condition would not exist, hence the maximum size of coarse aggregate should be about ½-in. less than the thickness of the structure.

Briefly, the usual construction procedure consists in spreading the coarse aggregate by hand or machine upon the base and rolling it in place until firm, then applying the binder at the rate of 1¼ to 1¾ gal. per sq. yd. Coarse chips or key stone is then applied uniformly over the surface in just sufficient quantity to fill the surface voids. These are rolled firmly in place and another application of binder is made at the rate of ½ to ¾ gal. per sq. yd. This is followed immediately by a layer of small chips from ¾ to ¼-in. in size, which is rolled in place with a slight excess of mineral that gradually crushes under traffic, forming a mat. An excellent method of construction does not stop here, but includes a second seal-coat after a month or so of traffic. Such a final seat-coat requires about ¼ to 1-3 gal. of binder per square yard and the usual chip top dressing.

Rolling is one of the most important items of construction. Tandem rollers should not be used. Rolling must be slow and thorough in order to provide the maximum of keying of stone. Depressions in the various layers must be corrected as the work progresses, course by course. Great care must be exercised in avoiding dirty or dusty aggregate, likewise the stone must be dry when binder is applied. Bituminous material —especially applied hot—will not adhere to dusty or dam aggregate.

Asphalt of 60 to 150 penetration may be used. Providing proper penetration into the structure is secured, the harder grades are to be preferred since greater stability results. Some engineers prefer a softer material for the seal-coat than is used in the first application.

This distinction is not thought necessary, providing care is used in applying the binder at a temperature of 300 to 350° F. on a clean, dry surface. The finest penetration work within the writer's experience employed an asphalt of 65 penetration. Under average conditions, the best results, no doubt, will

Edwardsburgh Road, South Bend, Ind., Black Base Over Old Gravel Road. Base Laid 2 Ft. Wider Than Sheet Top.

be secured by the use of a material of 80 to 100 penetration.

Cut-back and emulsified binders may be used for cold application penetration work; however, by far the majority of penetration work is of the hot application type and its use is probably attended with less hazard. In the case of small isolated jobs and maintenance work, cold application readily may have an advantage. Any form of macadam—bituminous or otherwise—will ravel rapidly under traffic once the surface is broken. For this reason repairs should be made promptly. In other words, the price of good bituminous macadam is systematic maintenance. If organized maintenance is provided, this type of pavement will give excellent service under a considerable volume of traffic.

Premixed Types for Cold Application.—Paving mixtures falling within this classification are really premixed macadam; that is, the mineral aggregate shows a preponderance of coarse particles with little or no fine aggregate. Such mixtures may be prepared at the site of the work or at a central plant and hauled to the work as needed. The well known cold-patch mixture is an example of type. The aggregates are mixed by hand or machine and cut-back or emulsified binder is added in sufficient amount to thoroughly coat all particles. The convenience of such preparations readily explains their popularity for repair work. Skilled labor is not required and plant and equipment is not at all expensive or complex. A considerable quantity may be prepared in advance and stored for use as needed, providing the solvent used is not too volatile. This type of mixture functions well for temporary repairs to most all types of pavement such as portland cement concrete, brick, block and the various asphalt surfacings; also is suitable for repairing depressions in various forms of macadam and gravel roadways prior to surface treatment.

Hot Application Premixed Macadam.—Premixed macadam is also frequently prepared and applied hot. In some localities this is quite a popular type of surfacing. Its manufacture and application is quite similar to that employed in such hot-mix types as asphaltic concrete and sheet asphalt, minus the refinement in grading of aggregate and with little or no fine aggregate. Furthermore, plant and equipment is not quite so elaborate. A seal-coat and chip dressing is essential as in the case of penetration macadam.

Hot-Mix Type Asphalt Paving Mixture.—Asphalt paving mixtures of the hot-mix type comprise a number of variations of two distinct kinds—sheet asphalt and asphaltic concrete. Stone-filled sheet asphalt, which is sometimes given as a third type, is in reality sheet asphalt with a small amount of ¼ and ½-in. stone added. There are and have been from time to time various patented modifications of the two major types. These, however, will not be discussed here since their manufacture and application follow so closely that which is in general use with all types of hot mixed asphalt pavements. In fact, it may be fairly stated that all have grown out of the original sheet asphalt mixture.

In the discussion which follows, it will be understood that in general the same type of mixing plant and laying equipment will apply to all types of hot-mix asphalt pavements; likewise the same grades of asphalt cement can be rather generally used without special discrimination as to exact type of mixture, climate and traffic being prime factors which govern the use of certain grades of materials. In reality hot-mix asphalt pavements are concretes, differing as to major types only in the character and degree of fineness of the aggregate, all aggregates being selected and prepared so as to produce a mixture with as low voids as possible, and with the amount of bitumen designed to approximately fill the voids in the mineral, binding the same together in place and rendering the whole a workable and compressible composition, and thus developing a dense structure by means of compaction under rollers of from 8 to 12 tons weight. Sheet asphalt does not contain crushed stone in the wearing surface, but consists of asphalt cement, mineral filter and graded sand. This absence of stone constitutes the distinguishing difference between sheet asphalt and asphaltic concrete.

Plant.—The plant for manufacturing mixtures at a temperature of 250 to 400° F. in the main consists of:

Kettles for melting the asphalt cement.

Storage tanks for asphalt.

Revolving drier of the drum type for drying and heating the aggregates.

Elevators for transporting aggregates to drier and from drier to storage bin.

Overhead screens for separating hot aggregates into various sizes.

Overhead storage bin for retaining separated aggregates for a short period in advance of weighing the batch.

Weighing box for accurately measuring the aggregates, suspended in or resting upon scales.

Bucket with scale attached for accurately weighing the asphalt cement.

Mixer of either the twin pubmill or rotary pressure type.

Power for operating the various units of the plant.

The above, of course, can be amplified by materials-handling machinery, and the like.

Equipment.—In addition to the usual layout of fire-pan, irons, tampers, shovels, rakes, etc., the equipment will include:

At least 2 rollers of 10-ton or more weight; one of them being the 3-wheeled type and the other a tandem. Additional rollers will be required in proportion to the volume of work done per day.

Rakers' sandals equipped with iron pegs about 2½-in. long to prevent tramping down the hot mixture.

A wooden lute of light construction for smoothing the freshly raked surface just in advance of rolling.

A complete set of laboratory sieves and screens for testing aggregates.

Laboratory scales.

A penetrometer for measuring the consistency of the asphalt cement.

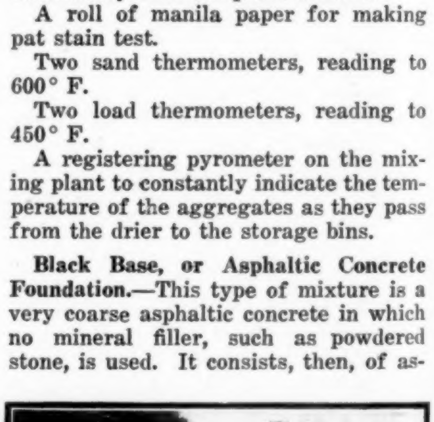
A roll of manila paper for making pat stain test.

Two sand thermometers, reading to 600° F.

Two load thermometers, reading to 450° F.

A registering pyrometer on the mixing plant to constantly indicate the temperature of the aggregates as they pass from the drier to the storage bins.

Black Base, or Asphaltic Concrete Foundation.—This type of mixture is a very coarse asphaltic concrete in which no mineral filler, such as powdered stone, is used. It consists, then, of asphalt cement, sand and crushed rock or gravel. The maximum size of aggregate permissible depends upon the total thickness of the structure or upon the number of layers and thickness of same.



Laying 1.5 In. Sheet Top on Black Base on Edwardsburgh Road. Note Edging Boards Spiked to Base as Construction Guides.

In other words, it may be built in one or more courses or layers of compressed mixture. In some localities black base mixture is merely the ordinary mixture used for binder course in sheet asphalt work with no increase in the size of the coarse aggregate. This, however, is considered inferior to the mixture contain-

Stone-Filled Sheet Asphalt on Black Base Resurfacing of Old Gravel Roadway, Michigan State Trunk Highway 23.

ing larger coarse aggregate of 2½ to 3-in. maximum size, graded down to ¼-in. The coarse aggregate should be selected with a view to proper size so as to reduce the voids to as low a point as possible. Crushed stone of various kinds, such as limestone, trap, granite, gravel, mixture of crushed and uncrushed material (with about 50 per cent of the particles crushed); slag, etc., make excellent coarse aggregates for this type of mixture. One item of economy in the use of the larger sized coarse aggregate results in less asphalt owing to the fact that well graded materials with these larger sized particles will be lower in voids so that it will not be necessary to use as much asphalt as will be required for smaller sized stone. A thoroughly satisfactory specification for black base mixture is as follows:

	Per Cent.
Bitumen	3.5 to 5.0
Sand (passing 10-mesh)	25.0 to 35.
Stone (passing 2.5 in. circular screen and retained on 10-mesh)	61.5 to 69.5

The sand should not be too fine, but should show a goodly amount of material retained on 40-50 mesh screen. Ordinary concrete sand makes an excellent fine aggregate for black base.

The preparation of the mixture is exactly as described later on for binder and wearing surface mixtures. Likewise it is laid and rolled in the usual way. Four to 5 in. can successfully be laid in one course. Beyond this thickness it is ordinarily deemed advisable to lay the foundation in two or more courses, say, 3 to 4 in. at a time. Each individual layer should be considered as a unit during construction and so laid and rolled, and being allowed to cool to air temperature before applying the second course, thus avoiding any disturbance of the lower course. Any unevenness which occurs during the rolling should be corrected at once, as each course is laid and not be permitted to remain for correction with a succeeding course or wearing surface. This is a very important item in the construction of all types of pavement work.

Black base provides an excellent foundation for almost any type of wearing surface, including the asphaltic types and brick and block as well.

Asphaltic Concrete.—There are two principal kinds of asphaltic concrete surfacing, the coarse aggregate and the fine aggregate types. The former contains less bitumen, sand and filler and more coarse aggregate of larger maximum dimensions, usually up to 1¼ in., whereas the latter contains nothing larger than ¾-in. and with 80 to 85 per cent of the coarse aggregate passing a ½-in. screen. The coarse type requires a seal-coat, while the fine may be finished with a brush coat of dry portland cement.

Asphaltic concrete surfacing may be laid upon most any kind of base, such as portland cement concrete, black base, macadam, gravel, etc. It is also readily adaptable for resurfacing all types of old pavement. The use of a binder course is not essential, but is frequently used, more often with the finer mixture than with the coarse.

On account of the presence of a considerable amount of comparatively large stone particles which would tend to abrade under traffic, it is important in all asphaltic concrete mixtures to secure hard, durable aggregate. Trap rock granite, crushed boulders or good quality gravel and hard limestone make excellent aggregates. Soft grades of limestone, however, are not considered sufficiently durable for this type of mixture. In localities where suitable aggregates are available, asphaltic concrete has become a very popular type of pavement and its service record over a period of many years amply warrants the selection of such type. By carefully proportioning the aggregates to produce the minimum of voids both as to the total voidage and the size of the individual voids and the use of durable aggregates, an extremely dense and stable mixture can be developed. Two typical analyses of asphaltic concrete mixtures are given below. The first is an excellent, well balanced mix of the coarse aggregate type and the second one of the finer aggregate type with a comparatively high percentage of stone, i. e., material retained on a 10-mesh screen:

Coarse Aggregate Type

			Pct.
Bitumen			5.7
Passing	200-mesh		9.0
"	80	"	10.3
"	40	"	10.1
"	10	"	8.1
"	4	"	12.8
"	2	"	17.6
"	¾	"	16.4
"	1	"	10.0
Specific gravity of rolled mixture			2.42

Trap rock aggregate laid on state trunk highway carrying large volume of traffic. Laid on binder course.

Giving excellent service.

Fine Aggregate Type

			Pct.
Bitumen			5.9
Passing	200-mesh		14.3
"	80	"	10.5
"	40	"	17.8
"	10	"	10.2
"	4	"	22.9
"	2	"	13.4
"	¾	"	5.0

Crushed granite coarse aggregate laid on heavy traffic thoroughfare in city of Chicago. Laid on binder course.

Given excellent service.

It is understood, of course, that the two examples given above are subject to considerable variations as to actual percentages on the different screen sizes, bitumen content, etc., depending upon the nature of the materials used. They do, however, illustrate dense, durable mixtures of these two types.

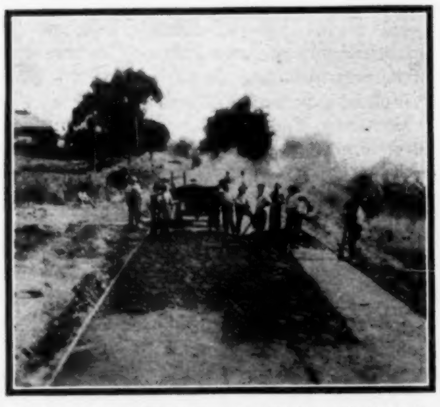
Mixtures containing less than 30 per cent stone are in reality stone-filled sheet asphalt mixtures. Those carrying 30-40 per cent stone of the smaller sizes —¼ and ½ in. with possibly some ¾ in.—fall into what is commonly known as the Topeka mix or a modification thereof. In some localities this latter is a very popular type of construction. It is not usually laid with a seal of asphalt cement but is merely finished with a light brushing of Portland cement. This type of mixture with a small amount of stone functions best when laid on a binder course, however, the binder is not absolutely necessary for light and moderate traffic. Two examples are given below, one of the stone-filled sheet and the other a Topeka type, both typical of their types:

Stone-Filled Sheet Asphalt

			Pct.
Bitumen			9.4
Passing	200-mesh		14.3
"	80	"	16.3
"	40	"	24.6
"	10	"	15.9
"	4	"	14.7
"	2	"	4.8

Topeka Mix Type

			Pct.
Bitumen			7.4
Passing	200-mesh		10.8
"	80	"	12.4
"	40	"	16.0
"	10	"	14.9
"	4	"	13.1
"	2	"	13.7
"	¾	"	11.7



Laying 5.5 In. Black Base on Native Black Soil; Brush College Road, Decatur, Ill.

The method of preparing and laying asphaltic concrete mixtures is identical to that which applies to sheet asphalt and therefore it will be discussed as applying to all hot mix asphaltic type

pavements under the caption "Sheet Asphalt."

Sheet Asphalt.—Sheet asphalt is the oldest standard hot mix asphaltic type pavement surfacing. It is rarely laid without the use of an intermediate or binder course and, therefore, any discussion of this type should include as an integral part thereof, the asphaltic concrete binder course which is laid directly upon the foundation and upon which in turn is laid the sheet asphalt wearing surface. The binder course is simply a somewhat less refined asphaltic concrete mixture than is necessary when used as a wearing surface. Ordinarily it contains no mineral filler but is composed, as in the case of black base, of asphalt cement, sand and coarse aggregate. Sheet asphalt is the most widely used and popular type of asphalt surfacing and it is also the most serviceable and permanent type. There are localities, of course, where sand suitable for sheet asphalt is not readily available and on the other hand aggregates suitable for asphaltic concretes are available and it will, in such instances, be more economical to select asphaltic concrete in preference to sheet asphalt. Other things being equal, however, sheet asphalt mixtures cost no more per inch of depth than asphaltic concrete and really offer in the long run, longer life and better service. It is, therefore, classified as the highest type of hot mix asphalt pavement surfacing.

Binder Course.—The binder course is the stabilizing or intermediate course between the foundation and the wearing surface. It adds considerably to the value of a pavement due to an increase in the thickness of the pavement and also because of its stabilizing effect. Such an intermediate course is not required when the wearing surface is laid directly upon a black base as a positive bond is secured between the wearing surface and such a base. The binder course is essential, however, when the surfacing is to be laid over rigid or semi-rigid type of foundation and is particularly advantageous in connection with resurfacing work where varying thickness is required on account of the uneven surface of the old pavement to be covered.

Ordinarily uncrushed aggregate should not be used in binder mixtures. It is imperative that at least 50 per cent of the particles should have angular faces. The mixture should contain a sufficient amount of sand or fine aggregate to produce a well balanced asphaltic concrete of high density and low permeability in order, first, to produce as stable a mixture as possible which will not compress or move under traffic and, second, to produce a water-tight mixture which will prevent the entrance of moisture. The importance of this last feature, namely porosity, can readily be appreciated by examining the binder course under old asphalt pavements laid many years ago when what is known as "openbinder" was ordinarily employed; i. e., a binder containing only a small amount of fine aggregate. In such cases if there was moisture present, it will be noted that the binder has almost completely disintegrated. This destructive action of moisture is greatly minimized, if not entirely eliminated, in a dense, close mixture. It is for this reason primarily that what is commonly known as "closed-binder" is now used in preference to the old type open binder. A well balanced, dense binder mixture will result from the following formula:

	Per Cent
Bitumen	4.5 to 5.5
Sand (passing 10-mesh sieve)	25.0 to 30.0
Stone (passing 1¼ in. screen)	65.0 to 70.0

Penetration at 77° F, 100/5	30 to 70
Flash point, open cup method	Not less than 375° F
Ductility at 77° F	Not less than 30 cms
Loss 5 hrs. at 325° F (50 gms)	Not more than 8 per cent
Penetration after 5 hrs. loss	at least 50 per cent of original
Bitumen (Sol. CS_2) Sol in CCl_4	Not less than 98.5 per cent

It being understood that the stone portion should be graded from 1¼ in. down to ¼ in. Extreme refinement of the sand portion of the mixture is not considered necessary as in the case of the wearing surface. Ordinary concrete sand usually makes a good fine aggregate for binder. Likewise sands which are somewhat finer are also suitable. Any well balanced binder mixture should have an appreciable amount of mineral passing the 10-mesh, ¼ and ½ in. screens. Binder course is usually laid 1.5 in. thick, therefore 1¼ in. should be the greatest dimension in the coarse aggregate and 80 to 90 per cent of the coarse aggregate should pass a 1 in. screen.

A typical analysis of a well graded binder mixture is as follows:

	Pct.	
Bitumen	4.8	
Passing 200-mesh	3.0	
" 80 "	3.7	
" 40 "	8.3	
" 10 "	12.1	
		Pct.
	Sand portion	27.1
	Pct.	
Passing 4-mesh	15.5	
" 2 "	16.8	
" ¾ "	18.7	
" 1" "	17.1	
		Pct.
	Stone portion	68.1

The plant formula for the above mixture was:

Asphaltic cement	50 lb.
Sand	300 "
Stone	650 "
	1000 lb.

While it is, of course, desirable to use a good grade of aggregate, it is not as necessary to have quite as hard and durable mineral as would be required in the wearing surface. The aggregate, however, should not be so soft as to show any signs of crushing under the rollers. A good grade of blast furnace slag in addition to crushed rock, gravel, etc., makes an excellent aggregate for a binder mixture.

While the surfacing of the binder does not require the same extreme care as the topping, yet it is necessary to evenly distribute and thoroughly rake the hot mixture in place, taking care to eliminate any pockets showing segregation of the coarse particles, depressed areas which are below the grade and contour, in other words, the surface of the binder after rolling should present an even, smooth contour. Slight depressions should not be left to be corrected in the wearing surface.

Sheet Asphalt Wearing Surface.—A number of items pertaining to all hot mixed types of asphalt pavements will be discussed under sheet asphalt with the understanding that they will apply to the types previously mentioned.

Asphaltic Cement.—The asphaltic cement should be of standard quality and of such characteristics as would comply with the following specifications:

The penetration of the asphalt cement, or its consistency, has a material effect upon the stability of the mixture. For this reason the consistency becomes an important design factor especially with reference to traffic requirements. In general, the heavier and denser the traffic to be accommodated, the lower should be the penetration of the asphalt. For ordinary requirements, however, it will not be found necessary to use an asphalt cement of lower than 40 penetration at 77° F. It must be appreciated that while the softness or hardness of the asphalt has a bearing upon the stability of a given mixture, this factor must never be used alone for the purpose of increasing the mixture stability. It is to be regarded more in the light of a factor of safety in the hands of experienced technologists. The stability of the mixture resides principally in the composition of the mineral portion thereof rather than in the asphalt itself and the mixture must be designed with this primarily in mind. In short, it is entirely possible to design a mixture by regulating the grading of the sand and the relation of the sand to the filler, to produce high stability and still use asphalt cement of fairly high penetration. The matter of mixture stability should be considered in this light rather than attempt to increase stability by simply hardening the asphalt as trouble will always result from this practice.

There is considerable misconception in the minds of many regarding the matter of penetration or consistency of an asphalt with relation to the tendency of the surface mixture to crack. That is to say, it is ordinarily understood that the harder the asphalt, the greater is the tendency of the mixture to crack. Within certain limitations, this, of course, is true; however, it is common knowledge that if the base under an asphalt pavement cracks, it is impossible to prevent cracking in the wearing surface regardless of the penetration of the asphalt. Take for example Ken-

tucky rock asphalt in which the bitumen is extremely soft—in some cases as much as 300. When this material is laid on a concrete base which cracks, it will show cracks at regular intervals, duplicating the cracks in the base. Likewise asphalt of extremely low penetration, say 25 to 30, laid upon a foundation which does not crack, will not cause cracking in the surface mixture. Mixture cracking, exclusive of reproduction of base cracks, is primarily a function of the mixture structure and not of the component asphalt although it is possible to use an asphalt which would crack, but such a material would not meet standard specifications requirements for paving asphalt. In designating the limits of penetration, one should bear in mind the commercial grades of 40 to 50, 50 to 60, etc. Asphalt of 50 to 60 grade will be found to suit a great many traffic requirements. Without doubt a larger amount of material of this grade is used than of any other.

Mineral Filler.—Quite a number of powdered materials make excellent fillers for hot mix asphaltic wearing surfaces such as limestone dust, slate dust, Portland cement, raw cement, slag dust, hydrated lime, etc. Ground limestone dust is perhaps the most widely used owing to its common availability and high value as a filler material. The chief function of a filler in asphalt mixtures is to reduce the voids in the aggregates both as to total volume of voids and the size of the individual voids. Its function in reducing the size of the individual voids increases the resistance of the mixture to displacement or increases its stability due to the fact that the distance between the points of contact in the mineral aggregate is much reduced. Asphalt functioning as a cement produces its greatest resistance to stress over short distances, in other words, it is an example of the effect of glue in thin films vs. thick films. Hence other things being equal, the filler which possesses the greatest void-reducing ability is usually the best filler. Specifications usually require that a filler should have at least 70 per cent passing a 200-mesh screen. This requirement alone, however, by no means insures the best filler. The important feature here is that such portion of the filler as passes the 200-mesh sieve should be properly graded down to the microscopic sizes. There are certain fillers which show 100 per cent passing the 200-mesh sieve, yet they are not nearly as good fillers as some showing only 605 passing that size sieve, due to the fact that the former usually have a preponderence of one size with the result that their void-reducing ability is greatly lessened.

In designing a mixture, the amount and kind of filler is one of the most important items providing the proper amount of bitumen is used. Insufficient bitumen naturally results in a dry mixture which is not susceptible to proper compression and, therefore, cracks and ravels badly. Any asphalt mixture should carry all of the bitumen it will hold without showing any excess as that is the life of the pavement. Overloading a mixture with bitumen is just as disastrous as the reverse. Such mixtures will tend to distort under traffic. A mixture must be both workable and compressible.

Until recent years the function of fillers was not very well understood; in fact, there is still a large amount of research work necessary in this connection; however, we do possess a rather clear understanding of fillers and a close student of asphalt paving mixtures readily appreciates the fact that the filler is an extremely important component of the final mixture and by a judicious manipulation of same, he has in his grasp the power to pre-determine the stability and durability of the final product to a very large extent.

Sand.—Sand suitable for sheet asphalt is also suitable for binder and asphaltic concrete and it will, therefore, be discussed under the one heading. Rarely is a sand found of proper mesh composition so that a mixture of another sand is not required. Such sands do occur, however, and when they are available considerable economy results, particularly with respect to the handling of materials at the asphalt plant. However, it is usually necessary to mix two and sometimes three sands to produce the proper mesh requirement. In proportioning sands, one should bear in mind that the ratio should be as simple as possible owing to the personal equation of the workmen around the plant. In other words, a simple relationship such as 2 to 1, 3 to 2, etc., should be used when possible in order to secure the maximum of accuracy in compounding. Considerable latitude is permissible with respect to exact mesh composition of the sand which will make a good mixture. It is, however, very necessary to remember that an extreme variation from very fine to very coarse particles of sand greatly affect the voidage and compressibility of the final mixture. For the purpose of comparison, 4 sand gradings are given in Table I.

Table I

	1	2	3	4
	Pct.	Pct.	Pct.	Pct.
Passing 200-mesh	0.0	7.5	0.7	0.0
" 80 "	34.0	34.0	28.8	2.2
" 40 "	43.0	34.4	38.5	26.9
" 10 "	23.0	23.0	32.0	70.9
Retained 10-mesh	......	1.1	......	......
Spec. Gravity	2.63	2.64	2.67	2.62
Per cent Voids	30.7	29.6	30.5	24.5

All of these sands except No. 4 are suitable for sheet asphalt. Number 4 would require compounding with finer sand. It will be noted, however, that No. 4 has lower voids than any of the others, yet in combination with a fine filler material, a mixture would be produced which would be very difficult to compress and very hard to handle and lay. Many specifications require that there should not be more than 5 to 6 per cent material passing a 200-mesh sieve in the sand. This regulation is entirely unnecessary. If there is any stipulation in that direction, it should be at least 12 to 13 per cent. It is found in actual practice that a well graded sand showing a considerable amount of 200-mesh particles, say 10 to 12 per cent, really makes a better sand than one with less 200. It seems to take the filler better and makes a more workable mix. Sand No. 3 is decidedly superior to No. 1 although the two show almost the same voidage. Its superiority lies, however, in its ability to show a much greater reduction in voids upon the addition of filler. This illustrates the importance of the study of sand together with the filler in designing a mixture. The two are really inseparable as far as the final mixture is concerned.

Mixture Design.—Until recent years, the design of an asphalt paving mixture was largely a guessing contest. Through years of experience, it resolved itself into a "Rule of Thumb" proposition based essentially on certain known combinations of materials which had apparently produced satisfactory results under certain conditions. There was nothing like engineering precision applied. Today, however, by virtue of a better understanding of the voids in an aggregate and how to determine them, we have been enabled to develop a rational method of designing a final mixture which at least has some foundation in scientific fact and has the particular advantage of greatly simplifying and clarifying the matter of mixture design and also has the virtue of agreeing positively with field experience. The ancient surface-area theory of mixture design is readily shown to be wholly untenable as a major premise. Research has not progressed sufficiently far at this time to say absolutely that voidage is 100 per cent perfect. It is, however, sufficiently understood to be safe and practice over almost 10 years shows that it is highly practicable.

The usual procedure in designing a mixture is to study the aggregate in various combinations with filler and plotting a voidage curve for various percentages of filler. By this means the most desirable final aggregate proportion can readily be recognized. Then, knowing the specific gravity of the various components, a properly designed mixture can readily be calculated upon the basis of volume of voids to be filled with the cementing material. Owing to the difference in the expansion coefficient of asphalt cement and mineral aggregate (the asphalt expanding about 23 times as fast as the mineral), it is necessary to use just a trifle less asphalt than will fill the voids 100 per cent, in order to avoid a mixture which is too rich at the elevated temperatures at which it will be laid (300 to 400° F). Such a method of design is based upon actual data and is a far cry from the old style "cut-and-try" procedure. It

also has the great advantage of clearly demonstrating over a period of several years that formula developed in the laboratory works in the field. It is very evident from this discussion that the design of asphalt paving mixtures is an extremely important matter and should be handled only by technologists of the highest order.

The present tendency in mixture composition of sheet asphalt as well as asphaltic concrete is quite definitely toward considerably higher filler content than was the case some 10 or 15 years ago. This change has come about through extensive research work which has disclosed the fact that by this means much more stable mixtures may be developed. The following typical mixture analysis is taken from a pavement 7 years old, laid under heavy down-town city traffic. It has shown absolutely no tendency to distort under traffic (either standing or moving) and shows no cracks although it is laid on a Portland cement concrete foundation. Asphalt of 35 to 40 penetration was use.

	Pct.
Bitumen	9.4
Passing 200-mesh	27.6
" 80 "	18.2
" 40 "	26.3
" 10 "	17.0
" 4 "	1.5

Preparation and Laying.—The aggregates are heated in the drum or drier and are stored in overhead bins, being first assorted as to size, whereupon they are weighed out (according to the formula given) into the weight-box. The mineral filler is added by weight, cold, all other aggregates being heated to from 300 to 400° F. The entire mineral charge is then deposited in the mixer-box and mixed for a few seconds whereupon the asphalt cement, at 300 to 400° F, is added. This complete charge is then mixed for a period of at least one minute or until a homogeneous composition results. It is transported to the work in covered vehicles with which we are all familiar. In depositing on the street, it is important that the entire paving mixture be re-handled. This can be accomplished by either dumping upon movable platforms or depositing far enough away from its final position that it can be shoveled into place. Great skill is required in handling the material on the street. The men must be trained for their work. The shovelers must know just how to deposit the material to the best advantage for the rakers; the rakers, of course, must be thoroughly experienced with trained eyes for following the grade. It is important that the freshly deposited material be at a uniform denseness after raking, i. e., it must be thoroughly combed with the rakes. Immediately following the raking, the surface should be luted with a lightly constructed lute about 6 ft. in length, operated transversely of the pavement, each stroke overlapping the previous one. This operation tends to remove the little pockets or depressions which may have been caused by the back of the rakes. The advantage of the lute will be immediately apparent in the final surface of the finished pavement.

The roller applying the initial compression should proceed over the surface as soon as possible without showing any checking under the roller. Mixture which is rolled while too hot will, of course, check and blister. The first rolling should always be done with the slow moving, 3-wheeled roller weighing not less than 10 tons and preferably 12 to 15 tons. The final rolling, however, can best be done with the tandem type which can be maneuvered more readily than the other type. This roller should likewise be at least 10 tons in weight. Rolling should be kept up until all roller marks have disappeared and the pavement presents a firm, smooth surface. Portland cement should be swept over the finished surface after the first rolling.

Any honeycombed spots which may appear in the surface during rolling are always due to lack of compression in this particular locality. This can best be corrected by immediate application of fresh, hot material in a thin film, immediately being rolled into place. It is imperative that such pockets be taken care of at once, otherwise cups invariably develop in the finished pavement under traffic, which further compresses the mixture. Also in cold weather such areas are subject to ravelling. If sealed in the old way with smoothing irons, cups are immediately formed which never disappear from the pavement.

$18,000,000 Road Program in Kentucky.—A road building program in 110 counties and calling for the expenditure of $18,000,000 in the next thirteen months has been announced by the State Highway Commission of Kentucky. Among the highways which will be completed are the Kentucky-Virginia Highway from Lexington to Pound Gap, Va., the Garrett Highway from Lexington via Mount Sterling to Paintsville, the Cincinnati-Lookout Mountain Air-line from Lexington to the Tennessee line and a quick route from Lexington via Stanford and Liberty to Russell County. Between $4,000,000 and $5,000,000 will be spent in maintenance of roads already constructed. The commission has a total estimated sum available for maintenance and construction of $24,000,000, including gasoline tax, motor licenses and Federal aid.

Canadian Provinces Spent $45,563,000 in 1926.—Canadian Provinces spent $45,563,000 on highway construction and maintenance in 1926, nearly two-thirds of the total being devoted to the former purpose.

Handling Traffic During Road Oiling

During the present season the State Highway Commission of California will expend $600,000 in oil treating about 700 miles of crushed rock and gravel roads. In an effort to have this work handled in a manner that will reduce to a minimum the inconvenience to the traveling public, T. H. Dennis, Acting Maintenance Engineer of the Commission, has issued the following instructions to division engineers:

Our success in oiling and its continuation depend entirely on the way we handle traffic. If poorly handled, it may become so unpopular with the public that it will have to be abandoned. Therefore, let this part of the program receive your earnest consideration. The following suggestions are submitted as an aid in this work.

1. Where possible, use detours and see that they are adequately signed and the signs kept illuminated at night.

2. Keep the press and the auto clubs' representatives fully advised of these detours.

3. Where detours are lacking, oil short stretches of road half width and establish one-way traffic controls. Post flagmen on these controls to regulate and advise traffic. Printed cards, as per sample, passed out by flagmen may prove beneficial:

> **—ATTENTION—**
> **THIS ROAD IS BEING OIL TREATED. PLEASE EXTEND YOUR COOPERATION BY DRIVING SLOWLY AND COMPLYING WITH SIGNS.**
> **California Highway Commission.**

4. Where controls are impractical, screen both applications.

5. Before oiling, see that sufficient screenings are on hand.

6. If oil is flooded over road by unexpected rains, cover with screenings immediately and hold off traffic until covered.

7. Be prepared to screen oil on superelevated curves.

8. Place large 4 ft. x 6 ft. wooden warning signs some distance from each end of oiling operations and keep illuminated at night.

Place 15 in. x 24 in. cardboard warning signs at frequent intervals along the oiled roadway.

9. Have wooden signs neatly painted and cardboard signs printed.

All printed cards may be secured from this office on requisition.

Field Investigations of Gravel Deposits

Methods Employed by Engineers State Highway Commission of Wisconsin Described in Badger Highways

By EDWARD B. TOURTELLOT

Assistant Engineer, Division No. 1, Wisconsin State Highway Department

In preparing for a materials investigation, the materials engineer should first avail himself of all information which the geological survey has collected for the project under consideration, giving thorough study to the type of deposit anticipated, the proximity of locations recommended to water supply, haulage distance and conditions and other points pertinent to the project. Too much stress cannot be laid on the idea of adequate preparation and foreknowledge of the situation. The materials engineer should be fully familiar with the topography and geology of the section, traversed by the project, in order that he may exercise judgment in selecting test pit sites. Poor judgment in this connection will quite often cause a rejection of a worthy site, which, had it received careful thought, might have been developed and an appreciable savings effected. On the other hand, too often a location receives far more test pitting than should be given to it, thus giving rise to waste and extravagance.

Knowledge of Glacial Geology Desirable.—The engineer or individual who is to have charge of the final survey, following the investigation carried on by the Geology Department, need not be a geologist, but should have a clear knowledge of the conditions under which the topography was formed and materials, used for highway purposes, laid down. This will require an interest in and a study of geological history and especially of glacial geology. When gravel deposits of glacial origin are considered, the best and most practical source of knowledge will be found through close contact with the geologist making the preliminary investigation.

A thorough inspection of each project, in company with the state geologist or his assistant, prior to the survey of the geological department, will not only give the materials engineer a wealth of knowledge regarding the geology of the region, providing he is alert and aggressive, but will, by virtue of his engineering experience and judgment, give the geologist valuable aid in his work.

Such features as practical plant set-up, haul limits and conditions, adequate water supply, all of which affect the construction, must be taken into consideration and the engineer should be thoroughly familiar with and an authority on such details.

The limit to which the investigation should be conducted is an engineering problem and must be based on a comparative cost of commercial material against local material for that job.

The source of water supply for washing plant determines the size of the pipe line and the pumping equipment. The topography of the deposit and of the land adjacent will have a bearing on the arrangement of the plant equipment and operation.

The drainage conditions and area available for depositing over-burden must be considered since they have a direct influence on the production cost. All these are salient factors in materials investigation and to which the engineer must give his attention, at the same time applying the knowledge which he has acquired from the geologist to a full solution of the problem at hand.

After the geologist has completed his survey and is prepared to make his final report, the materials engineer should go over the ground with him and become acquainted with the situation as the geologist sees it. The recommendations which the geologist has to offer will be made much clearer in this way than they would be through reading his report.

The actual field methods used in connection with the materials investiga-

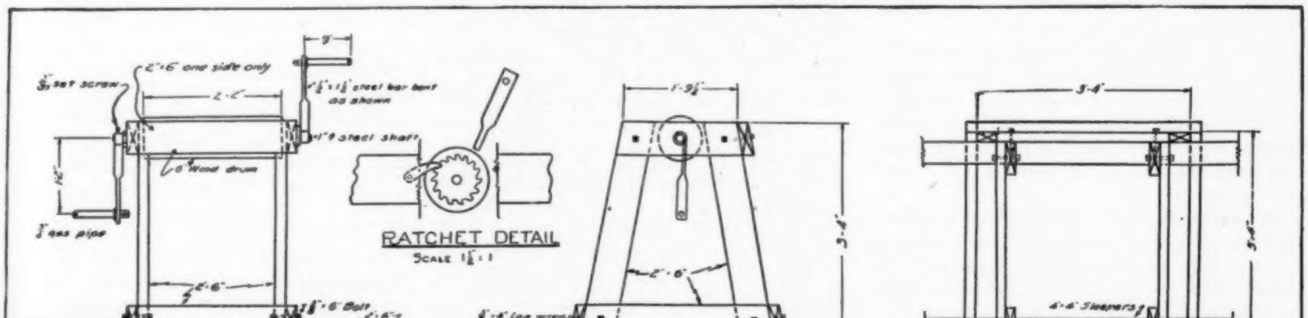


Fig. 1—Detailed Drawing of Windlass. A Diagonal Brace May Be Placed at Each End and One Side if Desired. The Bucket Shown Weighs about 16 Lb. The Sheathing Is 22 in. x 6 in. Stock.

tion will be taken up in the following paragraphs and the ideas and experiences gleaned from those who have conducted such surveys will be the basis for this discussion.

Organization of Field Party.—Each division office should have a complete organization for conducting field work. For gravel deposit investigation, there should be a crew consisting of a foreman and two helpers, together with the necessary equipment for carrying on the work. The field work should be commenced as early in the Spring as road conditions will permit. In this way test pitting of fields, which are to be under cultivation, can be completed before seeding is done. The engineer would do well to select these locations for either Spring or Fall testing, if possible to arrange the work in this way. However, it would not be practical to leave a location and return later, when crops were removed from the field, unless the crew was in the vicinity on other work. It would be better to pay the farmer damage to the crops rather than move the crew any appreciable distance.

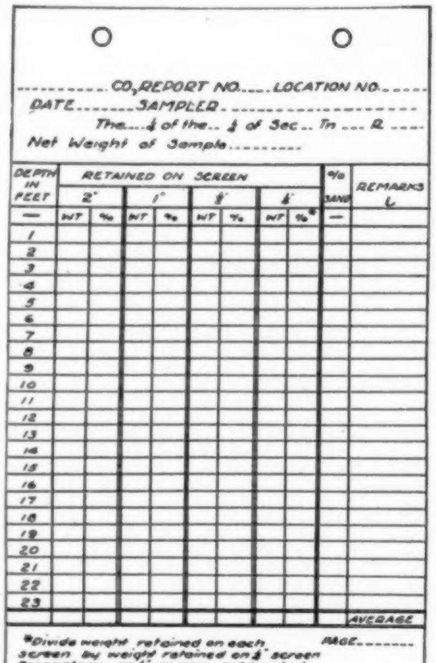
The writer believes that test pitting of locations for a proposed project should be completed a year ahead of the construction. This will allow ample time for the preparation of reports and the laboratory analysis of the materials. Too often, when time is limited, a favorable location may be overlooked or but partially test pitted. If the one crew in the division is unable to complete the work, additional men can often be secured from the county in which the test pitting is being done, especially in the Fall and early Winter when the construction work has shut down.

The division crew should be paid directly by the division and their time charged back to the project, whether it be federal, state or county. If additional help is required, this can be paid by voucher, either by the state or by the county.

Equipment for Field Party.—The equipment for gravel test pitting should include a truck, windlass or derrick, cribbing, small tools, field testing outfit, and instruments for mapping.

In general, from information given by the divisions, the truck in use by test pitting crews is a 1½ ton size of any standard make, preferably of the speed type. A very good suggestion given by Division 3 is to have compartments built for carrying scales, tools, samples and loose equipment. There should be a top over the body of the truck to protect equipment against weather. The compartments, containing the more valuable equipment such as scales, tapes, and other tools which are liable to be taken from the truck, should be padlocked.

Windlass.—The type of windlass which is suggested for use in connection with test pitting is illustrated in Fig. 1. The construction is of 2 in. x 6 in. lumber, secured by bolts and lag screws. The shaft, on which the cranks are secured, is one solid piece extending through the drum. The drum is made in two sections for this reason, and the sections secured with countersunk bolts. The windlass is placed on 4 in. x 4 in. timbers, laid across the top of the cribbing. These timbers are securely spiked to the 2 in. x 4 in. uprights, placed in each corner of the crib. A platform for the man operating the windlass can be made by nailing some of the 2 in. x 6 in. cribbing to the 4 in. x 4 in. timbers. A windlass of this type can be constructed for $18 complete.


..........CO., REPORT NO.....LOCATION NO.....
DATE..........SAMPLED..........
The....¼ of the...¼ of Sec...Tn....R....
Net Weight of Sample..........

DEPTH IN FEET	RETAINED ON SCREEN 2"		1"		½"		¼"		% SAND	REMARKS
—	WT	%	WT	%	WT	%	WT	%*	—	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
										AVERAGE

*Divide weight retained on each screen by weight retained on ¼" screen. Percentage on ¼" screen subtracted from 100% gives Sand per cent.
PAGE..........
Plate 6.

Fig. 2—Form for Recording Field Notes in Connection With Gravel Screening.

Division 3 suggests a combination windlass and derrick. The shaft of the windlass is a built up axle between two wagon or truck wheels, equipped with rubber tires. The derrick is to be built so that the wheels, with the drum mounted on the axle, could serve as a trailer. An "A" frame hinged to the axle, with a third leg, hinged at the apex of the "A" frame would make up the tripod. When a windlass only is required, the hoist is disengaged from the derrick frame. The shaft should be mounted on ball bearings and the cranks, for use in connection with the windlass drum, should be removable.

A detail of a bucket to be used with the windlass shown in Fig. 1 is included in this drawing. This bucket has a capacity of one cubic foot and is designed to stand up under the rough usage to which it is subjected. A ¾ in. rope will be found suitable for use with the hoisting equipment.

Derrick.—A derrick will be needed where vertical sheeting is used, especially for pulling the sheeting. For this purpose the tripod arrangement will prove more satisfactory than the crane type. The height of the derrick will depend somewhat on the length of the sheeting used. The derrick crane, consisting of a rotating post and projecting arm or jib, with the necessary tackle and windlass, is sometimes used for test pitting. This type has its advantages in that the boom arm swings free of the hole and lessens the chances of the loaded bucket falling upon the "bottom man." Another advantage is that the hoisting equipment and operator are not directly over the hole, thus insuring more safety to the man below. One disadvantage in the use of the derrick crane is its bulkiness. Not only is it necessary to have the post and boom of heavy timbers, well braced, but a counterweight must be placed on the back of the platform carrying the post. This type of derrick is inconvenient to move from one test pit to another and is objectionable in the truck because of its bulkiness and weight.

Cribbing.—There are two kinds of cribbing used in test pitting, the horizontal and vertical. The horizontal type is perhaps in more common use, owing to its adaptability and convenience in handling. A detail of the way in which the planks are sawed is shown in Fig. 1. This type of cribbing is similar to the old well curbing. It will be observed from the detail that the thrust is against the tongue, cut from the center of the plank, which is less liable to split than if left at the side. The cribbing is started at the top and carried down as the hole is dug, packing between the wall of the hole and the plank with hay, straw or grass. The hole should not be dug any larger than will allow for placing the cribbing in position, as too wide a space will require more packing material, and, unless the space is thoroughly filled, a bad cave-in may be expected. The length of the cribbing detailed will give a square hole 3 ft. 4 in. inside which is of ample size for a man to work. In order to hold the bottom plank in place, it has been found advantageous to nail lath in a vertical position to several of the cribs, placing one or more on each of the four sides of the hole. Blocks can also be used to hold up the bottom plank if desired. When the hole has reached a depth of 6 or 8 ft. it will be advisable to place a 2 x 4 in each corner, as this will not only stiffen the construction but will aid in keeping the shaft in alignment. In several cases, observed by the writer where 2 x 4s were not used in the corners, the cribbing shifted so much out of plumb, due to lateral pressure, that the holes had to be abandoned which resulted in a loss of the cribbing.

Horizontal cribbing has been successfully used by Division 1 for a depth of test pits from 20 to 30 ft. Where real coarse gravel is encountered

some difficulty may be expected as the material will have a tendency to cave. The care with which the space back of the cribbing is filled, will determine to a great extent the depth to which the pit can be successfully worked. Caution must be taken in packing the hay or straw so that the gravel will not be loosened and a cave-in result. It is not advisable to tamp the packing material from the top as this is almost sure to cause the gravel wall to slump.

The use of vertical cribbing has met with success in many places where it was necessary to carry the holes to a considerable depth and the gravel had a tendency to cave. The method employed by Division 2 is to use square frames, 4 ft. x 4 ft. outside dimensions, made up of 4 in. x 4 in. timbers, connected at the corners by 4 in. x 4 in. posts, spiked solidly together. The two frames and the posts can be built on top and set in place after the hole is excavated 5 or 6 ft. Care must be taken to have the frames plumb or the sheeting cannot be driven perpendicular. In the event the gravel stands without caving, the first set can be started at a lower depth. The sheeting should be of 2 in. x 6 in. stock, and 16 to 18 ft. long. Short pieces, 8 to 10 ft. long, can be used on one side or for a width of 2 ft., to permit the shoveling out of the gravel. It may be found more practical to use shorter lengths of sheetings, driving one on top of the other. These will be less bulky in moving, easier to pull and will permit of driving more readily than the longer lengths. As the hole deepened, the first sets of frames are lowered by striking them at the corners with a sledge. Additional sets and posts are placed in position above them and the sheeting driven down. The short pieces can be removed and substituted by full length pieces unless short sheeting is used throughout, in which case, the construction will be simplified. When it is necessary to go deeper than 20 ft., the frames should be 5 ft. x 5 ft. for the depth of the first set of sheeting. The frames below this are made 4 ft. x 4 ft. outside dimensions which will permit of driving the second set of sheeting inside of the first set. The excavated material can either be shoveled onto planks, placed across the 4 in. x 4 in. timbers, or removed with the use of a bucket and windlass. On account of the projecting of the sheeting above the ground level, it will scarcely be practical to use the windlass until the second set of sheeting is started. With shorter sheeting, a windlass and bucket can be used for the entire depth of the excavation. To remove the sheeting in the bottom set, it will be found advisable to fill the hole part way up on the sheeting, removing the frames as the hole is filled. The filling of the hole will tend to equalize the pressure on the sheeting and for this reason will make the pulling easier.

For horizontal cribbing operations, there should be at least 250 pieces made up. This number will sheet a hole 30 ft. in depth and give a few extra pieces for platforms, etc. The windlass will require 2—4 in. x 4 in. timbers 8 to 10 ft. long for supports, and for the corner braces, 8—2 in. x 4 ins.—12 ft. long will be needed. A few 2 in. x 10 in. plank should be carried with the equipment for protecting the pit and for general use.

Small Tools.—The small tools used by a gravel test pitting crew should include the following:

- 2—Round pointed short handled shovels
- 2—Round pointed long handled shovels
- 2—Picks
- 1—Auger
- 1—Post hole digger
- 1—Spoon shovel
- 1—Maul
- 1—Saw
- 1—Light crowbar
- 1—Hammer
- 1—Hand axe
- 1—Measuring rod, 1 in. x 2 in.—10 ft.

Miscellaneous items such as spikes, shingle nails, lath, sample sacks, tags, etc., should be a part of the equipment.

How Operations are Carried Out.—The method of constructing the cribbing for both horizontal and vertical types has been discussed in the preceding paragraphs.

The removal of the horizontal cribbing is accomplished by starting at the bottom and allowing the hole to fill in as the timbers are removed. In order to take no chance on a sudden cave-in, some foremen prefer to spear the cribbing, seated on a small platform in the shaft. The writer believes that this is an unnecessary precaution as little difficulty has been experienced in recovering the cribbing with the procedure above mentioned.

During the time that the test pit is left open, it should be enclosed by a three wire fence. Usually the owner will gladly furnish the material for this purpose, since he is interested not only in safeguarding his stock but in the outcome of the investigation as well. As an added precaution, the test pits should be covered over at night with planks.

The usual practice is to fill the holes as soon as the screen tests are made and samples taken for shipment to the laboratory. Some of the divisions have found it convenient to hire a farmer to fill the test pits, using a small slusher and team for this purpose.

Winter Methods.—In Division 7, their materials engineer states that the test pits have seldom been deeper than 12 to 14 ft. and a large percentage of the work of testing has been carried on during the winter months. His practice is to dig the test pits in successive stages, carrying a hole to a depth where the walls will stand without caving, protecting the bottom so it will not freeze, and then leave the pit a few days until the walls are frozen. On returning, the excavation is carried down to the second stage and the operation repeated. For a depth of 8 to 10 ft., the gravel can be thrown out but when this depth is exceeded, planks are laid across the top of the pit and hoisting equipment used. The holes are made large enough to allow a man to stand in the pit and throw the gravel out. This practice eliminates the use of cribbing and should prove worthy of consideration when the temperature is such as to keep the walls frozen. However, there is an element of chance in this method, especially if thawing weather were encountered.

Stripping Depth.—It is good policy to determine the depth of stripping or over-burden at different points between test pits. The best method for doing this is to dig a small hole, 3 or 4 ft. deep, using a round point shovel for the purpose and, for a depth greater than this, a spoon shovel or post hole digger. Auger borings have not proved satisfactory as the material removed is so mixed that it is difficult to determine whether gravel has been struck or the material is merely a gravelly till. Furthermore, where stones an inch or larger in size are encountered, the use of an auger will be found impracticable.

Samples, How Taken.—For field analysis where cribbing is used, samples of the material should be taken for each foot or 2 ft. interval as the pit is dug. If the material is quite uniform, every 2 ft. will suffice, however, if the material is not running uniformly, samples should be secured for each foot. The most practical way to do this is to fill the bucket with gravel from the bottom of the hole, after cleaning out the material which has caved down from the sides. Two buckets full for each sample will be sufficient. The use of a measuring pole, consisting of a 1 in. x 2 in. strip 10 ft. long and marked in feet, will be useful for determining the frequency of sampling. The top man should separate the samples, taken for each foot or 2 ft. of depth, marking each pile with a slip of paper showing the depth below the surface. When test pitting is done in shallow deposits, in which the gravel stands up and no cribbing is necessary, it is advisable to obtain a sample from each side of the pit by dragging the point of the shovel up the vertical face. The material should be stocked in a pile, thoroughly mixed and samples taken for both field and laboratory analysis. The quartering method for reducing the sample will be found practical. A mistake is quite often made in taking too small a sample from the walls of the pit, in which event there is usually a tendency to supply the defficiency from the general stock pile. Where vertical cribbing is used, a representative sample can be secured by pulling one or more of the cribbing

and taking the material out in the same manner as described above.

For laboratory analysis, there should be not less than 800 lb. of composite material collected and sacked. Most locations, where 4 or 5 test pits are dug, will require two samples of 100 lb. from each pit. Cement sacks will be found satisfactory for shipping material to the laboratory as they are made of heavy cloth and will not allow the sand to shift through. Each sack should be tagged, inside and outside, with tags furnished by the Materials Laboratory. The tag should show the name of the county, the owner of the deposit, the location and report numbers, test pit number, project or job number and the number and name of the road.

When samples are taken for each foot or 2-ft. intervals and separated in individual piles, as will be the case if horizontal cribbing is used, the sample for the laboratory should be a composite of all the piles. The writer does not believe it is necessary to separate the laboratory samples according to the depth. If two samples are marked as coming from one test pit, it will be understood by the laboratory that the material contained in both sacks is a composite sample for the full depth of the hole.

Size of Samples and Field Tests.—When cribbing is used, two buckets full of material should be taken for each foot or 2-ft. interval of depth. This will furnish from 100 to 150 lb. of gravel, depending on the size of the bucket, which can be reduced by the quartering method to a 25 or 40-lb. sample. A 40-lb. sample is recommended for screening tests in the field. A larger sample will be difficult to screen with the equipment at hand.

Screens.—The screens meeting the 1927 specifications should consist of five sizes, viz., 2-in., 1½-in., 1-in., ½-in. and ¼-in., with round openings. Type, 14½-in. x 14½-in. set in a collapsible wooden frame, has been extensively used for field screening. The frame is approximately 3 in. high and the screens are interchangeable in the frame. A groove is provided in the frame in which the screen fits. A heavy galvanized metal pan, slightly wider than the wooden frame and long enough to allow for shaking of the screen, should be provided to catch the material smaller than each size opening. A shelf is riveted on the inside of the pan to accommodate the frame. The box and cradle type of screen set is without doubt the most convenient outfit where speed is to be considered. This outfit is somewhat more cumbersome to move from one pit to another but the labor and time saved in its use will more than off-set this objection.

Scales.—The scales should be graduated to one-tenth of a pound, with a capacity of 50 or 60 lb., and provided with an adjustable pointer to set off the weight of the weighing pan. The circular, spring type scales are recommended for field use. Division 3 suggests the use of a 100-lb. pan scale of the lever type, providing the transportation equipment has the space for carrying this scale. There is an advantage in the use of this lever type of scale, as it can be placed on the ground or on a platform, while the spring balance type must be suspended from a tripod or raised by hand each time a sample is to be weighed. If the truck can be driven up to the test pits, little trouble will be had in rigging up a device from which to suspend the scales.

Recording Screen Analysis.—The recording of screen analyses should be made on a form similar to the one shown in Fig. 2. The net weight of the material retained on each screen, divided by the net weight larger than a ¼-in. screen, will give the actual percentages of the coarse aggregate for each screen size. This method will be found convenient in making a comparison with the sizes called for in the specifications as well as for checking with the laboratory analysis. The percentage of sand or fine aggregate is determined by subtracting the percentage retained on the ¼-in. screen from 100. Each interval of depth for which a sample is taken should be recorded and the average of the results taken.

To secure a sample of fine aggregate for field analysis, the writer would recommend taking a handful of material passing a ¼-in. screen, for each test run on the coarse aggregate and, after thoroughly mixing the sand, reduce the sample to the size desired. A piece of canvas should be carried with the screening equipment on which to spread the sand so that it may be dried out sufficiently to facilitate screening. A set of sand screens should include one each of the following sizes:

No. 10, No. 20, No. 50 and No. 100.

The 8-in. circular brass screen, with cover and bottom pan, is a convenient size for field use.

If there is evidence of rotten stones in the gravel, these should be picked out of the sample and the percent determined. The prevailing type of stones should also be ascertained and the percent of such to the total sample recorded. This is particularly important where igneous and metamorphic rocks are found to predominate, as is the case of the northern part of the state. These data are usually given in the geologist's report but the materials engineer will do well to verify this information. The maximum size and approximate percentage of stones larger than 3 in. should be observed and recorded as this information, as well as the prevailing type of stone, is of importance to the contractor in determining the size and capacity of the crushers.

Other Tests.—A colorimetric test and silt test should be made on the material from each test pit. These tests can, however, be best conducted by the laboratory and the results given the division office. A field test should be made to determine the organic matter in the water supply which is recommended. It will be more convenient for the materials engineer to secure a sample of the water, when he is making an inspection trip, and later to run the test in his office. The method given in the specifications, paragraph 51.3-e, should be followed. If there is an indication of organic matter, further tests should be made by the laboratory.

Mapping and Notes.—The equipment necessary for mapping a gravel deposit should consist of the following:

- 1—100-ft. metallic tape and extra filler
- 1—Hand level
- 1—Light transit with level attachment
- 1—Light tripod
- 1—Sectional level road
- 1—Note book cover, loose sheets, and report forms
- 1—Hand axe.

The loose leaves for the notes should include transit and level sheets, cross section paper, and analysis record sheets. Covers and stationery, used by the State Geological Survey, have been found adaptable for this work and, no doubt, arrangements can be made with this office to furnish such supplies.

Survey.—Two methods of making the survey of a location are practical, viz., the coordinate and stadia methods. The one employed will depend on the situation of the deposit, proximity of land lines and the preference which the engineer has in the matter. A location near a road or land line which affords a view of the deposit and immediate vicinity, will be an ideal condition for the use of the stadia method. If contours are to be mapped, the stadia method will be found practical. The writer has used both methods and has no choice to offer. The plotting of the field notes is somewhat simplified when the coordinate method is used.

Levels should be run to show the elevation of the ground at test pit sites, tops of old pit faces and floors, outlet road, proposed plant set-up and terrace line. Elevations for showing a cross section and longitudinal section of the deposit are indispensable if an accurate measurement of the yardage is to be made. Contours are very convenient for showing the topography, especially the drainage conditions and facilities for plant set-up, and if time will permit, it is policy to get this data.

The survey should locate all adjacent land lines, buildings, roads, worked gravel pits, test pits, streams, outlet road and any other topographic features which will have a bearing on the working of the deposit. The names and addresses of property owners should not be overlooked.

The location of a water supply, adequate for the requirements of the washing plant, is an important item. The

distance from the deposit, the approximate quantity available, possibilities for ponding and the presence or absence of organic matter, are of particular interest to the contractor and should be recorded. The type, length, and condition of the outlet road with recommendations for improving, together with the maximum grade to be expected, should be noted. Other items to be considered are probable plant set-up, drainage from the washing plant, possibilities for disposing of stripping and sand waste, and facilities for stock piling the aggregate.

If a producing plant is in operation, a brief description should be given in the notes, covering the type, size and capacity of screens, crushers and washing equipment. This information will be of worth if the remodeling of the plant is to be considered. Photographs of equipment in use and of the deposit in general will add very much to the report and this practice should be encouraged where particular emphasis is to be given to a certain feature or peculiarity of the location.

Arbitration for State Highway Contracts

New Law in North Dakota

A new law passed by the legislature of North Dakota provides the machinery for the arbitration of disputes arising between the state highway commission and contractors. The text of the law follows:

House Bill No. 261

An act authorizing and providing for the submission of controversies between the state highway commission of the state of North Dakota and parties contracting therewith to arbitration, and providing for the entry of judgment as in cases of arbitration between other parties and providing for the enforcement of such judgments.

Section 1. All controversies arising out of any contract for the construction or repair of highways entered into by the state highway commission of the state of North Dakota shall be submitted to arbitration as hereinafter provided, if the parties cannot otherwise agree. Three persons shall compose the arbitration board, one of whom shall be appointed by each of the parties and the two thus appointed shall name a third.

Section 2. The party desiring arbitration shall make a written demand therefor and shall in such demand name the arbitrator by him selected. He shall also in such demand set forth all the controversies and claims which he desires to submit to arbitration and a concise statement of his claim with reference to such controversies. Such demand shall be served upon the opposite party, who shall, within 10 days, name in writing the arbitrator on his part, and in connection therewith shall set forth in writing his contentions with reference to the claims set forth in the demand served upon him and any additional claims or controversies which he desires to submit to arbitration on his part, with a concise statement of his claims in connection therewith. Provided, however, if the party proceeded against shall fail or refuse to name an arbitrator the moving party may apply ex parte to the judge of the district court of the county in which the improvement in the contract in question, or any part thereof, may be located for the appointment of two additional arbitrators, and if upon the appointment of an arbitrator by each of the parties, the two so appointed have been unable to agree upon a third arbitrator within five days, then either party to the controversy may, upon five days' notice, apply to such district court for the appointment of such third arbitrator.

Section 3. When such board of arbitration shall have been appointed, a submission in writing shall be executed as provided by section 8328 compiled laws of 1913, except that such submission must provide for the entry of judgment upon the award by the district court of the county within which the improvement, or some part thereof, involved in the contract is located, which county must be specified in such submission, and which submission must be executed on the part of the state highway commission by some member thereof to be selected by such commission. Thereupon the aribtration shall proceed in accordance with the provision of chapter 40 of the code of civil procedure of the compiled laws of 1913.

Section 4. If either party refuses to submit to arbitration as hereinbefore provided he shall be deemed to have waived all claims and demands, and the arbitrators shall proceed to determine the controversies set forth by the moving party according to the justice of the case, and judgment shall be entered upon the award of such arbitrators in all things the same as though the submission to arbitration had been signed by both parties.

Section 5. No right shall exist to demand arbitration against the state highway commission until the following conditions shall have been complied with; that is, the contractor must give the commission notice in writing that he claims the contract has been or will be fully performed on a day stated, which shall not be less than 10 days after the giving of such notice. At the time stated in the notice the commission shall cause the work to be inspected, and if it claims the work has not been completed it shall with all reasonable dispatch, having regard to the early completion of the work, specify the particulars in which it is incomplete and direct that it be completed accordingly, or if it considers further work necessary to bring the project up to the desired standard for acceptance either by it or the United States Bureau of Public Roads, even though it considers such contract complete, it may likewise specify any such additional work, and the contractor must proceed with all reasonable dispatch, having due regard to weather conditions, with the performance of all such additional work with a view to a speedy completion of the project. When the contractor claims in good faith, supported by the affidavit furnished to the commission, that he has completed such additional work according to the specifications furnished him and the commission fails for 10 days to accept such work as completed, he shall have the right to institute proceedings hereunder. The arbitrators shall then determine all controversies between the parties growing out of the contract, including the question whether it had been performed at the time claimed by the contractor and whether the additional work required by the commission as specified has been done, and if not it shall specify the particulars in which it has not been done and give appropriate directions with reference thereto, and shall make a proper award for any extra work it finds the contractor entitled to, making such award so far as is practicable upon the basis of the contract price, having due regard to what is just and equitable between the parties under the facts and circumstances of the case. Provided, however, in any case where controversy already exists at the time of this act taking effect and it is claimed by the contractor that the contract has been performed and he has removed his equipment from the job, arbitration may be had and all controversy settled without obligation on his part to do extra work as aforesaid.

If after the making of an award which requires the contractor to do further work, any controversies arise between the parties as to the doing of such work, such controversies may be submitted to the same arbitrators on five days' notice for further determination.

Section 6. No arbitration shall be had hereunder unless commenced within six months after the right thereto has arisen, except in the case of controversies already existing in which case it may be commenced at any time within six months after the taking effect hereof.

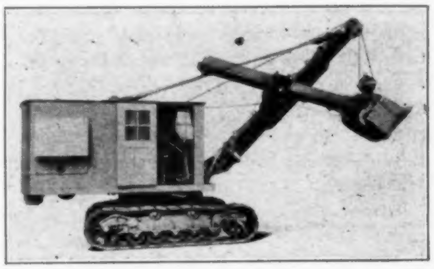
Section 7. When judgment shall have been entered against the highway commission the same shall not be collectable or enforcible by execution, but if the same provides for the payment of money by the highway commission it shall be paid in the same manner, to the same extent and out of the same funds as though the claims thus established had been recognized and allowed without arbitration, and the performance of the duty of the highway commission with reference to payment or other compliance with such judgment may be enforced by mandamus proceedings in the district courts of the states.

Section 8. Inasmuch as there is doubt and difference of opinion as to whether the state highway commission may sue or be sued in the courts of the state, and as to whether compulsory arbitration may be resorted to for or against it, and there are substantial and important disputes pending between such commission and persons who have contracted with it, this act is declared to be an emergency measure and shall be in full force and effect immediately upon its passage and approval.

Koehring Brings Out New Shovel-Crane-Dragline

The Koehring Co., Milwaukee, manufacturers of pavers, mixers, gasoline shovels, cranes, and draglines, has just announced its new No. 501 machine. The No. 501, which is built as either a shovel, crane, or dragline, as specified, is a machine with capacities ranging from 1½ to 1 cu. yd. of material.

An innovation in this machine is the



View of the New Koehring Shovel

method of rating the shovel. The choice of three sizes of dippers may be had depending upon the length of the dipper sticks and the kind of work for which the machine is to be used. With 13 ft. sticks a 1½ cu. yd. dipper is furnished; with 16 ft. sticks, 1¼ and with 19 ft. sticks, 1 cu. yd. dipper. The boom length is 24 ft. in each case.

Other profit-making features designed to increase the output and yield larger returns to the owner, are the Koehring shovel power dipper trip, the special swiveling boom point fairlead for the dragline, cast steel carbody, multiplane girders and side frames, ball bearing-mounted high speed shafts and roller bearing-mounted vertical traction and swing shafts. A Koehring-Wisconsin four cylinder 6 in. x 7 in. gasoline engine, running at 925 R.P.M., furnishes the power, with an optional choice of electric motor.

A smaller size machine, No. 301, with capacities ranging from 1 cu. yd. to ⅝ cu. yd. is also built.

American Road Builders Launch Safety Campaign.—Plans were formulated at the recent annual meeting of the American Road Builders' Association in Washington, D. C., to conduct a nation-wide campaign for the promotion of safety. Reports were presented to the highway commissioners and engineers showing that in the five-year period ended Jan. 1 last more than 112,000 persons had been killed in highway accidents, most of which were avoidable. Of these deaths 30,000 were children under 14 years of age. During that period more than 3,500,000 persons were injured in motor accidents.

Highway Maintenance

Some Costs on Minor Items in Wyoming Given in Wyoming Roads

By G. W. MARKS
District Highway Engineer, Rawlins, Wyo.

Maintenance is one of the big items to be considered by any going concern and failure to provide for this is one of the causes of bankruptcy in many of our industries. The highway department is no exception to this rule and if adequate provision is not made it is only a matter of time when the money that has been expended for construction will be a partial if not total loss.

The popular idea of maintenance is hauling a drag or grader up and down the road in any manner that will smooth it and repeat the operation again when necessary.

When a road is completed it then becomes the duty of the maintenance department to keep it in the condition it was in when turned over to them. This does not mean surface maintenance only, but also ditches must be kept clean, culverts maintained, structures painted and repaired, embankments reshouldered, surfacing replaced and direction and warning signs replaced and painted.

Below is an estimate of cost of maintaining a mile of average Federal Aid Highway in this state. The fact that the department has been spending less than half this amount is not evidence that the estimate is too high, but rather that through lack of funds it has been compelled to postpone the work that will eventually have to be done.

As above stated, there are several kinds of maintenance, so we will first consider surface maintenance.

In most parts of Wyoming the nature of the country is such that it is impractical to use horses for pulling drags or graders. The cost of getting feed and water on the job makes this prohibitive, consequently most of this work is done by trucks or tractors.

The cost of operating a truck and drag or grader is from $18 to $26 per day; this includes salary of operator, gas, oil, depreciation and upkeep of equipment. To do good work a truck should not drag faster than four miles per hour and must make at least two round trips over the road to properly smooth the surface and remove excess loose material back to the side of the road. When one considers time lost going to and from work and other delays, a patrolman does a good day's work if he averages six miles of road a day. This makes a minimum cost of $3 to place one mile in condition.

Some of our main traveled highways should be gone over three times a week during seasons of heavy travel, wet or windy weather. It is believed that the average road should be dragged at least every five days. This would make an average daily cost of 60 ct. per day for the season.

There are about 240 days of heavy maintenance in this state, consequently there should be available about $144 per mile year for this class of work.

Ditch Maintenance.—A highway without proper drainage is little better than no highway and ditches that are not kept clean and repaired soon cease to handle the work they are intended to.

There are two kinds of ditches: (1) surface ditches that are intended to carry the water that may fall above the roadway, from and to the culverts that cross the high way, and (2) side ditches that carry the water that may fall on the roadway itself.

The maintenance on the former is not very great, although rains may make expensive repairs necessary. However the latter require frequent blading to remove weeds and dirt that collect.

The average cost of cleaning and maintaining ditches is about $12 per mile of highway per year.

Culverts. — During the winter the snow drifts into culverts and then we have a thaw or two and water will run in and ice will form when it again freezes. If this were allowed to remain until spring run off started, extensive damage would result. During summer weeds and dirt collect and must be removed before freezing up time. In various ways end walls are damaged and must be repaired. All this will probably cost about $1.50 for each culvert, and as there are about 10 culverts to the mile, that will make a cost of $15 per mile for culvert maintenance.

Structures.—A great many of our bridges were built several years ago and were not designed to carry the loads they are now required to. These are now being replaced as fast as finances will permit, but until satisfactory structures are built we must maintain the ones we have.

The cost of replacing worn-out decks, broken stringers and rotten piling, as well as repainting, is considerable. To this we add the cost of painting and repairing guard rail. The past season the cost of this work on state highways in Carbon County averaged a little over $12 per mile.

Reshouldering Embankment. — Wind, rain and stock are constantly wearing away the sides of embankment and this must be replaced. For this work we use tractors and heavy graders, except on high grades, and here we use teams and fresno.

Where we can use tractors this work will cost about $40 per mile, but when teams are used it will cost from $100 to $200. A fair average would be about $75 per mile, and as this has to be done about every three years, it would make an annual cost of $25 per mile.

Replacing Surfacing.—The average person is of the opinion that when gravel is once placed all that is necessary is that it be dragged every few days to be kept in condition.

It is estimated that the loss from wear under the present high speed and heavy traffic is from 5 to 10 per cent. The standard yardage per mile is a little over 1700 and the minimum cost of gravel in place is about $2 per yd. and considerable of it will cost $6 to $7, due to long haul. This would make a minimum cost of $170 per year per mile for gravel replacement.

Another item that is overlooked is binder. Those who have driven much in a location that has little wind will have noticed that during dry weather there is a thick layer of dust lying on the road. This is something seldom seen in most parts of Wyoming, as the prevailing wind removes this as fast as it is made.

It is the binder that holds the gravel together, and if it is not replaced we would soon have our roads covered with loose material which would not only be unpleasant to drive on, but would also be dangerous.

The replacing and mixing of this binder will cost at least $10 per mile per year. This brings our gravel maintenance up to $180 per mile per year.

Direction and Warning Signs.—The chief cause of damage to our signs is from so-called sportsmen who use them for targets, also stock find them handy to rub the loose hair off their heads and necks.

The annual cost of maintaining our signs will probably run about $3 per mile.

Each district has a maintenance foreman experienced in all classes of maintenance work. His duties are to supervise all maintenance work in the district, to inspect all structures regularly and thoroughly, to provide warning of danger until it can be removed, to see that all men under him take proper care of their equipment, to make emergency repairs to equipment that his men are unable to make and, above all, to instruct new men in his employ.

To sum up we have as follows:

		Pct.
Surface maintenance	$144.00	34.8
Ditch maintenance	12.00	2.9
Culvert maintenance	15.00	3.6
Structure maintenance	12.00	2.9
Reshouldering	25.00	6.0
Replacing surfacing	180.00	43.4
Sign maintenance	3.00	.7
Total	$391.00	
Supervision 6 per cent	23.46	5.7
Total one mile maintenance for one year	$414.46	100.0

The above does not take into account snow removal in the winter or washout or accidents that might be the cause of additional expense, but may be taken as an average on those routes having a traffic which does not exceed 500 vehicles per day.

Highway Maintenance in Pennsylvania

Methods of State Highway Department Summarized in Paper Presented Before American Road Builders' Association

By WILLIAM H. CONNELL

Engineering Executive, Pennsylvania Department of Highways

The guiding principle in repairs performed by the forces of the Pennsylvania department of highways is "A stitch in time saves nine."

In general, the methods and system by which this work is carried out are as follows:

Earth Roads.—The earth road mileage is divided into patrolmen's sections varying in lengths from 5 to 20 miles. The scraping and dragging equipment is assigned to each section and is operated under the direction of the patrolman. In the spring of the year, the earth roads are scraped and crowned, the early scraping being performed by tractor drawn blade machines in order that the ditches may be thoroughly cleaned and that new material may be pulled in from the slopes to build up the road. The dragging operation follows the scraping and crowning and is performed with team drawn drags while the road is still moist. The earth roads are always dragged after rains. Occasionally throughout the year it is necessary to give the roads a light scraping. This is done with team drawn scrapers, truck drawn scrapers or light power graders.

Oiling Earth Roads.—In June, all the earth roads carrying any considerable amount of traffic are oiled to lay the dust. A light asphaltic oil is applied cold at the rate of approximately 1/5 to 1/4 gal. per square yard. It is desirable that the road be damp, but not wet, when it is oiled. An application is effective from one to two months, depending upon the weather and traffic conditions. Two applications are usually applied each season.

Calcium chloride is used for dust laying to a limited extent, generally only on roads which are well shaded. When an earth road is very dry, it should be sprinkled before the calcium chloride is applied. The first application is at the rate of 1½ lb. per square yard and subsequent applications are at the rate of 1 lb. per square yard. Two or three treatments are required each year. The material is applied by dumping it from a truck through a spreading device or an ordinary grain drill may be used.

Gravel Roads. — Gravel roads are scraped and crowned in the same manner as earth roads. They are usually oiled every year with a wax oil or a light tar applied cold. In cases where the road becomes very rough it is scraped or scarified and resurfaced with fresh gravel.

Shale Roads.—In one section of the state there is a light gray shale having excellent bonding qualities. The roads through this area have a natural surface of high quality and have been surface-treated for a number of years with a light cold tar applied at the rate of from 4/10 to 5/10 gal. per square yard. In the spring new shale is added from the road slopes. The road is then surface-treated. Repairs can generally be effected by adding fresh shale.

Oilbound Roads.—The oilbound road is a progressive improvement. This method was adopted a number of years ago for light traffic roads at a time when there were insufficient funds to provide a higher type of construction. This was fully justified at the time, but has been practically discontinued in recent years.

After shaping up the road and building the berms, about 3 in. of loose limestone, ranging in size from ⅝ in. to 1¼ in., were spread uniformly on the roadway. The road was then opened to traffic from three months to a year. In instances where it was only open to traffic for about three months before applying a treatment of about ¾ gal. of light tar, this was done without adding additional stone. Where the road was open to travel for several more months before the treatment of tar was applied, a few inches of additional loose limestone were added.

The method of the treatment was to apply about ¾ gal. of tar in two applications, the first consisting of approximately 4/10 gal. This was allowed to set for a few days, after which the road was rolled. The second application of about 3/10 gal. was then applied, after which the road was rolled and opened to traffic.

Each year for the following two years a few inches of loose limestone were added to the road, after which it was treated with about ½ gal. of light tar and then rolled. This resulted in a 6-in. stone road at the end of the third year.

After a period of years, the number of years depending upon the amount of traffic, these roads were resurfaced with bituminous surface-treated macadam and are today classed as bituminous surface-treated macadam roads.

This progressive construction in Pennsylvania served the traffic needs on light traffic roads at a time when it was necessary to use all available funds for construction on the heavily traveled roads.

Patching Oilbound Roads.—Oilbound roads are patched in several ways. Slight irregularities or shallow holes are painted with a heavy tar which is covered with chips and tamped. Larger holes are patched with mixed materials made up from stone and heavy tar mixed by hand or concrete mixer in the appropriate ratio of one ton of stone to 10 or 12 gal. of bituminous patching material, care being taken to keep the amount of tar used to a minimum to avoid the possibility of fatty patches. Mixed patching material should be allowed to set for a day or two after mixing in order that the more volatile oil may evaporate. When it is placed in the hole to be patched, it is tamped thoroughly. Great care must be taken that the amount of material placed in the hole is neither too much nor too little, as any variation from what is right will cause a bump in the road. The edges of the oilbound roads, and, in fact, of all the macadam roads break down under traffic, and it is necessary to build them up carefully by picking out the loose material along the broken edges and replacing it with mixed patching material.

Bituminous Surface-Treated Macadam.—The older roads had a 4-in. compacted top on a telford base. Later this type was built of a 6-in. uniform minimum thickness. The present design is a minimum cross section 7½ in. at the edges and 5½ in. in the center.

Patching of bituminous surface-treated macadam road is performed in the same manner as described under oilbound roads. It is particularly desirable to guard against an excessive amount of mixed patching on bituminous surface-treated macadam roads as there is a tendency in mixed patching to use too much bituminous material, which results in a patch softer than the original roadway. When an excessive number of patches would be necessary on a section of road, it is scarified and re-surfaced.

Surface Treatments.—A bituminous surface treatment on macadam roads is generally necessary every one to five years, depending on the amount of traffic. In Pennsylvania these treatments are either a light asphalt or tar, applied cold. The roadway surface is thoroughly swept and the treatment applied from a pressure distributor at a rate of from 2/10 to 35/100 gal. per sq. yd. on ½ the width of the roadway. Chipping at the rate of 15 to 30 lb. per sq. yd. follows immediately. The chipping is

generally done by mechanical chip spreaders or by hand shoveling from small piles placed about 20 ft. apart along the highway.

It is generally necessary, after the chipping by mechanical spreader has been done, to have one or two men follow up to broom back the chips and cover spots which may have been slighted by the mechanical spreaders. Sometimes it may be necessary for additional chipping to be done if the road bleeds. Only ½ of the road is surface-treated at one time and the other side is not treated until the first side has dried.

The underlying principle of bituminous surface treatment is to apply light applications and only as often as is necessary, the purpose being to avoid the possibility of building up a mat on the surface of the stone road.

Bituminous Macadam Pavements.—(Bituminous Penetration, Bituminous Concrete and Rock Asphalt Pavements)—Bituminous penetration pavements are surface-treated in a manner similar to the bituminous surface-treated macadam. More extensive repairs are made with the same material and in a manner similar to the original construction.

Bituminous concrete pavements are surface-patched in a manner similar to surface-treated macadam pavements. More extensive patching is done with a cold mix bituminous concrete or rock asphalt.

Rock asphalt repairs of all kinds are done with rock asphalt.

Bituminous surface treatments of penetration macadam and bituminous concrete roads are performed in the same manner and with the same materials as bituminous surface-treated macadam roads.

Concrete Pavements.—The cracks and joints in concrete pavements must be sealed two or three times a year; at least one sealing being required each spring and fall. Care must be observed that pouring is done only when the concrete is dry. The bituminous material used for joints in Pennsylvania is a medium asphalt, impregnated with mineral flour. It requires heating and should be thoroughly stirred before being placed in the pouring pots. Before new bituminous material is poured the joint is cleaned, old joint material is scraped off the surface and from the upper portion of the joint or crack. After the pouring the bituminous material is covered with sand to prevent tires from picking it out of the cracks and joints.

When concrete surfaces scale and the scaling is observed to be progressive a bituminous surface treatment is applied and covered with sand.

The most common breaks requiring repairs in concrete roads are either transverse breaks due to buckling or corner breaks. When the road buckles jacks are placed under the raised portion to support the pavement as the edges of the break in the raised portion are chipped away to allow the pavement to be lowered back to the established grade. Repairs to the pavement may be made in two ways. If the buckling has not been excessive and it is not necessary to chip back the edge of the raised portion for any great distance, the small space remaining between the edges of the break after the pavement has been lowered into position is filled with a bituminous paving material, which remains as a permanent filling. If the buckling has resulted in excessive breaks in the pavement the concrete is trimmed back as far as necessary and the surface is made vertical. The pavement under each side of the break is then undercut for a distance of 6 in. and a depth of 6 in. and the space under and between the edges of the slabs is then filled with a concrete patch in which is set the standard joint filler used in construction work.

In repairing corner breaks, the broken portion, usually triangular in shape, is removed and the edges of the slab adjacent to the break are squared and made vertical. This space is then filled with a standard concrete mix, the patch being 6 in. thicker than the adjacent slab, and underpinning the edges of the slab for a distance of 6 in.

Berms.—On state highway maintenance work, berms constitute an important part of the maintenance work, and one which can easily be overdone. Berm maintenance may be very economical or very expensive, depending on whether or not the fullest possible utilization is made of mechanical methods. In Pennsylvania, hand labor has been practically eliminated. Earth berms are maintained with a light horse-drawn scraper or motorized grader. Where the road is of sufficient width to adequately carry the traffic, it is cheaper to maintain a grassed berm than an earth berm. Grassed berms are maintained by an occasional mowing. The problem of keeping the berms built up adjacent to the pavement presents more difficulties along the rigid types of highway.

Ditches.—Ditches should be maintained by the use of scrapers in so far as practical. Hand work will be necessary, of course, in the vicinity of headwalls. The weeds and brush in most cases should be cut twice a year for the sake of appearances and at least once a year for drainage purposes and to lessen the possibility of the brush along the road having the effect of a snow fence placed too close to the road so that snow is deposited on the road. This work is done by mowing machines as a general rule.

Traffic Aids.—Thirty thousand direction, warning and historical signs have been erected on the Pennsylvania highways. Traffic lines have been painted to separate the traffic lanes, at all road intersections, horizontal and vertical curves, and grade crossings, and at 300 ft. from all grade crossings and road intersections an advance warning has been painted on the pavement.

To make night driving safe, reflector signs have been placed at dangerous points, and poles along the highway have been whitewashed; on curves where there are no poles, large stones or fences have been whitewashed.

Guard Rail.—That guard rail erection is a matter of moment in Pennsylvania may be seen from the fact that about $1,600,000 was expended during the past four years in erecting approximately 700 miles. This large sum of money was not spent, however, until much study and many tests had been made. The result was a change in standard from a cable guard made up of two ¾-in. cables to a design having a lower cable ¾ in. thick and an upper cable 1 in. thick. A change was also worked out in the anchoring system. The new design affords much greater protection against the tendency of a truck to knock down and pass over the guard. At present the cables pass through holes bored in the supporting posts, but the department has been making tests of various clamps designed to hold the cables on the inner side and away from the posts so that vehicles hitting the fence at an acute angle will slide along the cable without striking the post with a hub.

City Pavements.—The same general principles can be applied to any system of highways with modifications to suit local conditions. The biggest problem in the cities, for example, is the maintenance of the stone block and asphalt pavements on a concrete base.

Asphalt pavements are generally repaired in one or two ways; either by cutting out portions of the surface or by the use of a surface heater. Minor repairs are generally made by the cut-out method. Such an organization uses an air compressor for cutting out the material to be removed.

More extensive repairs are now done with a surface heater method. This consists of heating the surface with the surface heater, raking off the top and replacing it with new material.

The repairs of brick, stone and wooden block pavements are made in cities in two ways, depending upon the area to be repaired. For large areas, large gangs are used, each gang having an air compressor for boring out the blocks and breaking down the concrete base where this may be necessary. In restoring the concrete base on large projects, ready mixed concrete is used. The restoration of trench openings, service cuts and scattered depressions is done by small gangs of paver, rammer and laborers. Concrete which it may be necessary to replace is hand-mixed on the job, if less than a cubic yard of concrete is involved.

Snow Removal.—The snow removal work in Pennsylvania is operated under what has been generally known as the

"Snow Alarm System." At each equipment shed throughout the state during the winter a watchman is on duty and as soon as the snow begins to fall he notifies the superintendent, who is also advised by the daily notices from the nearest weather bureau of the probability of snow. As soon as a storm seems likely to be of any magnitude the superintendent arranges to assemble his men and when the snow attains a depth of 2 in. snow removal forces start to work and continue working day and night, if necessary, until the roads are open to travel. Thousands of men are continuously employed fighting the storm rather than waiting until the snow ceases to fall before starting the removal work. Many times, of course, this work is carried on in the coldest weather and the men work day and night with practically no rest, battling the elements until they have conquered the storm. This, of course, is as it should be. The department is a service department. Its duty is to provide highway transportation needs; that means all year round travelable roads.

Snow removal is a phase of maintenance which is receiving more and more attention each year in Pennsylvania. Four years ago 1,400 miles of hard-surfaced road were on the snow removal program. At the present time the program calls for snow removal on 6,340 miles, which includes virtually all the completed hard-surfaced roads in the state, except in some sections where the hard surfacing of the through routes has not been completed.

About 1,500,000 ft. of snow fence have been placed in locations where trouble has always been encountered from drifting snow. "An ounce of prevention is worth a pound of cure," and one of the cheapest things that the highway department buys is snow fence as it saves hundreds of thousands of dollars which would otherwise have to be spent in snow removal.

Two types of plows are in general use, the moldboard plow and the V-type plow. Rotary plows are used in a few districts where there are frequent heavy snowfalls. Moldboard plows are pushed by trucks and are effective as long as the snowfall is light. They will not push the snow off the road when the snow pushed to the side has become deep or is heavily packed.

The V-type plows on the other hand have an adjustable wing to throw the snow in the air as it is pushed to the side. These plows are operated by trucks or tractors and will handle a more severe storm than the moldboard equipment.

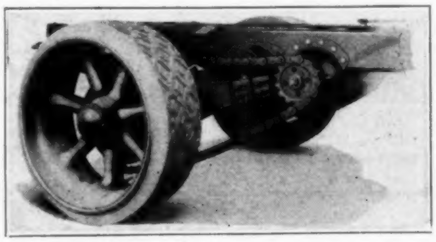
Four wheel drive trucks are used for snow removal work as they are more effective than the two wheel drive trucks, due to the additional traction on slippery pavement.

Snow removal work in cities is handled under the same general snow alarm system, but the snow not only must be removed to the side of the road by plows, but in some large cities it is entirely removed from the streets. In others it is removed from the streets in business sections and main thoroughfares. This requires an army of workers and, of course, is far more costly than state highway snow removal.

The far reaching importance of this work demonstrates the necessity for having it cared for by a well trained organization prepared to meet emergencies as they arise. Technical knowledge is fundamental in handling this work, but it is also a big operating and organization problem, and the success with which it is operated is dependent upon the effectiveness of the methods and procedure pursued in the performance of the work.

Two New Chain-Drive International Trucks Announced

Two new types of four-cylinder dump trucks with nominal ratings of 2½ tons and 3½ tons respectively have recently



Detailed View of the Chain Drive, with Adjusting Feature in the Radius Arm

been added to the line of motor trucks manufactured by the International Harvester Co. The smaller of these, designated as Model 54-C, has a capacity of from 2½ to 3 yd., and the larger, designated as Model 74-C, 4 to 5 yd.

Both models are provided with a wide range of gear ratios so that when necessary a maximum of power can be exerted in pulling up steep grades and at other times a fair rate of speed with a minimum of fuel consumption can be attained on level and easy-going stretches. The transmission includes four speeds forward and one reverse. In the larger Model 74-C truck, in addition to the reduction gear type of drive, the live axle has a two-speed range, which provides a wide choice of power applications.

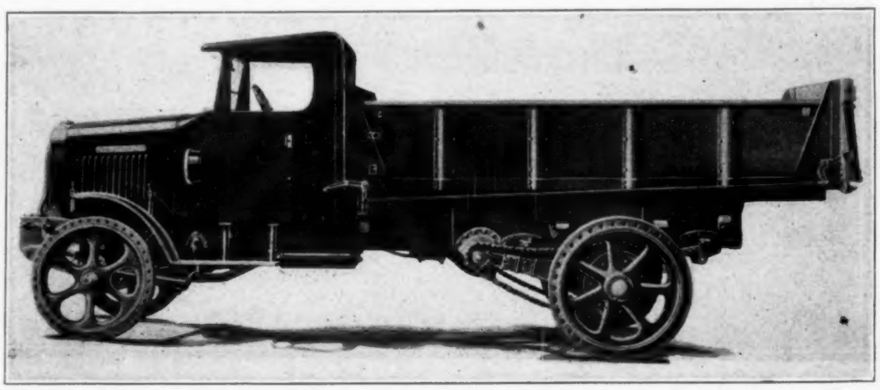
A very simple arrangement for adjusting the tension of the chains is incorporated in the steel radius arm, which transmits the torque from the rear wheels to the frame.

Removable cylinders; worm and wheel steering gear, with post carrying wheel at a 30-degree angle and connecting shaft vertical, thus giving maximum foot clearance, comfort, and convenience for the driver; and auxiliary rear springs that go into action after the load reaches a certain amount, thereby providing additional cushioning effect when loads are heavy, are features included in these new models.

The frame consists of deep double steel channels, one inside the other, each section being ¼-in. thick, and a liberal number of cross members that give the entire chassis great rigidity.

With these two additions, International Harvester trucks are available in sizes for virtually every hauling need, ranging in capacities from the ¾-ton Special Delivery to the 5-ton heavy-duty model, with a variety of chassis and body types to choose from. Moreover, with these two new chain-drive Internationals available, the prospective purchaser can make his choice from two types of International Harvester heavy-duty trucks, either the new chain drive or the standard double reduction drive, which has been used during the past several years by numerous contractors for heavy material haulage work all over the country.

City Manager Bill in Illinois.—A bill is before the state legislature of Illinois to extend to all cities of less than 500,000 population the opportunity to adopt city manager government. Under its provisions, the council will vary in number in accordance with the number of inhabitants. At present, the city manager form is optional for cities of less than 5,000 population only.



The New Model 74-C International Chain-Drive Truck

Dirt Road Maintenance

How Rhode Island City Uses Asphaltic Surfacing Material

By E. E. DURFEE
City Engineer and Highway Surveyor, Cranston, R. I.

Dirt roads in the country district of the City of Cranston, R. I., have been maintained for the past two years by the use of an asphaltic surfacing material containing 55 per cent of asphalt. The cost of upkeep has been reduced by the following method: The roads were first scraped with an ordinary road machine, all unevenness being taken out and the road properly crowned before the surfacing material was applied. The oil was applied by a pressure distributor at the rate of ½ gal. per sq. yd. Due to the soft condition of the road after scraping, it was not necessary to cover with sand except in spots where the road material was hard. These places were given 48 hours to absorb the oil, after which they were given a light coat of sand.

Fig. 2—Large Banks Rapidly Cut as Shown Here.

In about three months, there developed a number of pot holes, where the oil had been picked up by passing teams, or where, due to the condition of the road, the oil failed to stick. These pot holes were patched with a mixture of sand and Texaco liquid asphalt No. 1, which contains approximately 65 per cent of asphalt. By means of a small concrete mixer, the sand was mixed with enough oil to give it a dark brown color. This patching material was just thrown into the holes, and soon compacted under the traffic so that no traces of the patches could be found.

The spring season of the second year, we found the roads in rather bad condition, due to the frost and winter travel. There was, however, a considerable amount of oiled surface still existing but we found no difficulty in again scraping and re-shaping with the road machine. This mixture of dirt and oil, after being scraped, left a splendid surface for the new application. In some places there showed from 1 to 2 in. of this dirt and asphaltic surfacing material mixture where the road machine had pulled it into holes or ruts. The roads were treated with Texaco No. 55 surfacing material as before. Very little difficulty was experienced the second year with pot holes.

The roads have all been scraped this spring, ready for the third application of oil. From all appearances, we will have a mat of sufficient thickness to withstand any traffic the roads will be called upon to carry.

Due to the hard appearance of the surface at this time, we contemplate using Texaco liquid asphalt, a heavier material than No. 55 surfacing material, and covering it with sand for this season.

The opening of the new reservoir by the Providence Water Supply Board at the end of one of these roads has increased the auto traffic by thousands, yet very little difficulty was found in keeping the road in condition. A section of this road left untreated has gone to pieces under the heavy automobile traffic.

Dirt Road After Scraping, and Ready for Third Annual Treatment With Texaco Surfacing Material

Tennessee Legislature Authorizes $65,000,000 of Bond Issues.—The general assembly of 1927 of Tennessee authorized bond issues totaling $65,000,000. These included $16,500,000 to take over the county highway bonds, $22,825,000 for roads, $11,806,000 for bridges, $9,780,000 for schoolhouses and courthouses and $4,371,000 for waterworks and sewers of various municipalities.

Joint Pavement Construction by County and Cities

How Cook County, Illinois, Handles Joint Construction Within Its Towns and Cities Described in Paper Presented Before Illinois Society of Engineers

By DUNCAN M. CAMPBELL

Supervising Engineer, Office of Superintendent of Highways of Cook County, Illinois

The location of Cook County, on Lake Michigan, has limited the trend of population and industrial development to three directions: north, west and south. The development in these directions is indicated by the expansion of the city of Chicago from a small section located in the vicinity of the present "Loop" district to its present area of over 200 square miles. The city includes approximately 20 per cent of the land area and 88.5 per cent of the population of the county. In spite of this great increase in area, population and industrial development have expanded beyond the political limits of the city and, in an economic sense, Chicago includes a large number of cities and villages which are contiguous to the city proper.

84 Cities and Villages in County.—There are 84 incorporated cities and villages, exclusive of Chicago, in Cook County. Three of these cities and villages have a population in excess of 25,000 persons, eight a population in excess of 10,000 and fourteen a population in excess of 5,000. Of the 84 cities and villages, 50 are located within a zone five miles in width forming a belt around Chicago, and these fifty cities and villages have a population of approximately 75 per cent of the total population of the county, exclusive of the city of Chicago.

The large number of cities and villages surrounding the city intensifies the problem of providing highway service in this area. The growth of these cities and villages has made necessary the provision of direct highway routes between them and Chicago. At the same time, their development has produced congestion centers for local traffic on the principal thoroughfares of the county. The incorporation of these cities and villages has created a large number of separate jurisdictions and increased the difficulty of planning and constructing a unified and balanced highway system in the county. With these difficulties in mind, it has been the policy of the county board to encourage joint paving projects between the county and the various municipalities.

Municipal Widening Projects.—Cook County has been granted authority by the state legislature to construct "State Aid Roads' lying within the corporate limits of any city, village or town in the county. The cost of such roads for the same width and of the same materials as outside of the corporate limits, to be paid entirely by the county. By agreement between the county and the municipality a road or street of greater width and different materials may be constructed by the county through any city, village or town providing the municipality agree to pay the excess cost, if any, for the greater width or different material. These roads, after construction and acceptance, to be maintained within the corporate limits by the state highway department.

Since 1916, when Cook County first engaged in municipal widening projects, 34 cities and villages have been aided in constructing 54 miles of widened pavement. Most of this mileage has been constructed within the last three years. At the present time plans have been prepared for constructing 20 miles of widened pavement in 11 cities and villages.

Methods of Procedure for the Construction of a Pavement Jointly by Cook County and a Municipality.—The conditions under which a joint pavement is to be laid require that the plans and specifications for the entire improvement shall be prepared by the engineer for the city, village or town. The plans shall be complete and entire and be prepared in accordance with the standards of the state highway department. The municipal engineer is invited to confer with the engineer of design for the county highway department and the district engineer of the state highway department during the preparation of plans.

After completion of the plans, and before there are spread by the municipality the assessments, six sets of plans and specifications, together with a copy of the ordinance covering the improvement, shall be formally submitted to the county superintendent of highways for approval. The county superintendent of highways will examine and check the plans and shall notify the engineer in writing of his approval or disapproval.

The county highway department will mark upon the plans that portion of the work to be performed by Cook County, and, in addition thereto, a cover sheet or title page and a typical cross section of the county's portion of the improvement with the estimated quantities. The plans, specifications and ordinance shall then be formally submitted to the state highway department for approval. When approval by the state highway department has been obtained, a copy of the letter of approval, together with a set of the approved plans, shall be forwarded to the municipal engineer by the county superintendent of highways. It may be well to emphasize here that state aid roads built jointly with the county will be maintained by the state highway department after completion and acceptance, and that plans agreed upon will not be changed except upon written permission of Cook County and the State of Illinois.

Method of Spreading the Assessment.—Most municipalities encounter considerable difficulty in deciding upon a course of procedure for spreading the assessment. One of the following four methods may be used:

1. The assessment may be spread for the entire improvement and that part of the work paid for by Cook County considered as a public benefit.
2. The assessment may be spread for the entire improvement and a refund awarded to each person assessed.
3. The assessment may be spread only for that portion of the work to be done by the municipality.
4. The assessment may be spread for that portion of the work to be done by the municipality over the entire improvement.

It is also very necessary in preparing the contracts at this time that the county and the municipality make the award of a contract by one party contingent upon the award of a contract by the other party.

The municipality, after deciding upon a method, may now institute proceedings in the county court to spread the assessment. Upon the completion of the necessary legal requirements and when the municipality is in a position to proceed with the advertisement and award of the contract, it shall notify the superintendent of highways and it will be mutually arranged to take bids and award the contract. The County of Cook will award a separate contract for that portion of the pavement to be paved by the county and monthly estimate will be given the contracts for that portion of the work. It is the county's practice to award its contract to the successful low bidder, who receives the city or village contract, and at the same equivalent unit prices, providing that the unit prices are not in excess of the state approved estimate.

It also becomes necessary that the contract awarded by County of Cook again be approved by the state highway department before the contractor will be allowed to proceed with the work. The county will furnish cement to the contractor for that portion of the work to be done by the county. This cement will be obtained from the state

highway department only after approval of the contract and its award by the state highway department. All other materials ordered to be used in this work, whether in the municipality's portion or Cook County's portion of the work, shall be tested and inspected by the state highway department.

During the construction of the pavement, inspection will be furnished by the Cook County Highway Department. The setting of stakes and the establishment of grade lines shall be performed by the municipal engineer.

Instruction for Design of Pavement Through Municipalities.—Right-of-way: The right-of-way shall be a minimum of sixty feet in width except in special cases where the securing of such a width is impracticable. A width less than sixty feet will be accepted only after detailed investigation and after the issuance of a special permit therefor. Where it is necessary to open up new roads or new streets, the village or city will be expected to provide the necessary right-of-way in all cases.

2. Pavement: It is expressly understood that the county will pay for an amount of pavement equivalent in all respects to the Cook County standard 20-ft. concrete pavement, excepting at intersecting state aid roads, where the county will pay for an amount of pavement equivalent in all respects to the Cook County standard 40-ft. intersection with returns. This intersection provides a 40-ft. concrete pavement for a distance of 500 ft. each side of the intersection, tapering to 20 ft. in 300 ft. and with returns 40 ft. in width.

The minimum width of roadway shall be 40 ft. exclusive of curb and gutter. This provides for 4 traffic lanes, each to be 10 ft. in width. If the municipality desires to provide for parallel parking a lane 8 ft. in width is recommended. Diagonal parking is to be discouraged.

3. Grade Line: The county will participate in the improvement to the extent of laying the pavement to the municipalities' established grade. Approximately one-half the total yardage of excavation will be paid for by the county.

The grade line shall be established for the primary purpose of securing a smooth, easy riding pavement. The standard practice of the state highway department shall be followed as closely as physical conditions permit. The municipal engineer shall give particular attention to the following requirements:

Long tangents, minimum length of vertical curve 300 ft. maximum allowable grade 5 per cent, avoidance of level grades and maximum allowable grade at railroad approaches of 3 per cent with at least 50 ft. of level grade adjacent to track. Drainage of pavement will be obtained by varying the crown rather thin by the use of an undulating grade line. Chicago City Datum shall be used in the preparation of the plans for the improvement.

4. Bridges and Culverts: The minimum width of roadway on bridges shall be 44 ft. with two 5-ft. sidewalks. The expense for the construction of bridges will be paid by Cook County.

Culverts: Only the culverts necessary to carry the water across the street under improvement will be built by the county. All entrance culverts or culverts at intersecting roads as well as street intersections will be built only with the express understanding and agreement that the city or village will pay for their construction.

5. The county superintendent of highways will furnish the title page to accompany all plans, which will show the conventional symbols, state aid route number and section number.

6. A typical cross section of the improvement shall be placed on the first sheet directly following the title page. This section, on a suitable scale, should show the various slopes for cut and fill, the width of graded section in cut and on embankment, the crown or shape of the finished surface, shoulders, gutters, etc., between slopes, the width and thickness of the various courses of pavement or surfacing, together with any desired additional details.

When more than one typical cross section is used, the proposed location for each should be indicated.

On this sheet also will be shown, any special information, such as catchbasins, manholes, inlets, details of intersections, summary of quantities, etc.

7. The plan and profile shall be placed on the same sheet. The plan shall be shown across the top of the sheet and the corresponding profile directly below. When the conditions permit, without interference or overlapping, two sections of the plan and profile may be shown on the same sheet.

A suitable standard profile ruling may appear across the lower portion of the sheet if desired, but the upper portion showing the plan should in no case bear profile ruling.

8. The plans shall be drafted to a scale of 1 in.=100 ft., and the profile shall be drafted to the same horizontal scale as the plans and to a vertical scale having a ratio with the horizontal of 1 to 10. A distorted lateral scale must not be used.

9. The plan of the road shall show the center line of construction bearing of tangents, right-of-way lines, stations of beginning and ending of curves, approximate radii of curvature, station points, equations of stationing, streams and railroads on or near the right-of-way, poles for wire lines and other obstructions on the right-of-way. Structures outside of the right-of-way need be shown only when affected by the proposed construction. The location of proposed new culverts and bridges with their sizes, also the location and sizes of old culverts or bridges which are to be left in place and used, are to be shown. Any old road surfaces or portions of pavements to be used in place in connection with the proposed construction, and all unusual or special walls, ditch protection, and subdrains shall be shown. Such of these items as lend themselves readily to location by description may be tabulated or noted, but the tabulation or notation should appear on each sheet of the plan concerned. In minor changes of location requiring new or additional right-of-way, the margins of the old roadway shall be shown by light broken lines.

The plans should be platted with the stationing from left to right. A north point should be placed on each sheet. All curve points or angles on the construction line and the 100 or 500-ft. station points shall be marked.

10. The profile, in all cases, is to show surface line, grade line, length of vertical curves, percentage of gradient, datum line and station ordinance lines, as well as surface elevations and grade elevations at station ordinates, and at changes of gradient. The surface line of stream beds under existing bridges, as well as that of the bridge floors, shall be shown. Balanced points of excavation shall be indicated on the profile with the quantities involved.

The "Grade Line" shall represent the profile of the surface of the finished pavement.

The "Surface Line" shall represent the profile of the surface of the ground along the center of the present traveled way where the new location of the roadway is to be essentially the same as the old location, although the centers may deviate slightly. Where relocations or re-alignments are made which will cause the center line of the roadway to be essentially different from the center of the present traveled way, the surface line shall represent the profile of the ground along the center of the proposed roadway. The surface line is to be drawn as a series of straight lines. Cross sections shall be taken at intervals of 100 ft. The cross section shall be platted to a horizontal and vertical scale of 1 in.=5 ft. They shall be platted from the bottom of the sheet upward and so not to interfere unduly with one another. Either the lower side or the right hand end of the sheets may be used as the bottom in platting.

The cross sections shall be drafted to show the ground surface and the template lines of the proposed typical sections. In all cases the side slopes, ditches, etc., shall show; the ground line shall be extended slightly beyond the slope intersections. Each cross section shall be marked with its station number, "Grade line" elevation, surface elevation and cross sectional area in square feet of both cut and fill. Any additional information in square feet of both cut and fill. Any additional information may be shown.

Complete specifications for the improvement will accompany the plans and must adhere in detail to the standard specifications of the Cook County Highway Department.

Covering for Old Worn Concrete Roads

Extract from Committee Report Submitted at 6th Annual Meeting of Highway Research Bureau

There is no denying the fact that the construction of early concrete pavements was haphazard and the workmanship very poor. Riding quality was not so important as it now is, because traffic was nearly all horsedrawn, therefore slow moving. A surface that was satisfactory under slow-moving wheels became very disagreeable with the advent of the high-speed automobile. The quality of the materials used in construction did not receive the consideration deserved; as a matter of fact, pit run gravels were used in the construction of some of our heavily traveled roads. Where the sand to stone ratio approached the ideal, and the material was free from clay, good results were obtained. Where these conditions did not prevail, steel-tired traffic soon wore the surface down, and disintegration under impact took place rapidly. In the early stages of concrete paving construction, it was expected that the wear under steel tires would expose the coarse aggregate after the pavement has been in use one year. For this reason a hard tough coarse aggregate, as close to the surface as possible, was an important factor, for the reason that the surface mortar would wear off much more rapidly than the coarse aggregate.

In order to get the coarse aggregate as close to the surface as possible, the proportions were changed from 1:2:3½ to 1:2:4. This reduced the thickness of the mortar coat over the coarse aggregate and gave a pavement that stood wear much better than 1:2:3½.

Now that practically all freight and passenger traffic is carried on rubber tires, the wear on our concrete pavements is negligible. The marks of the finishing belt are still discernible on concrete pavements laid five years ago that carry very heavy traffic. It is universally conceded that modern concrete pavements do not wear out. The life of concrete pavement is a direct function of its rate of cracking. Deterioration, or cracking up, is brought about by temperature changes causing expansion and contraction, by impact from heavy loads at high speed and from subgrade disturbances. In general, the demand for a new surface is not because the sustaining power of the old slab is insufficient but because of the fact that the old surface is so rough as to make it uncomfortable to ride over, and the impact set up by this rough condition causes still further destruction.

Bringing Old Surface to True Profile.—In covering an old concrete pavement, which in the majority of cases is a matter of necessity due to roughness, some means must be devised that will permit adding enough material to the low places to smooth the old surfaces and bring the surface to a true profile before the finishing course is placed. The coarse aggregate in the binder course of asphaltic pavements is too large to permit of feathering to a thin edge. For this reason it is not desirable as an equalizer, because too large a quantity is required. The varying thickness of material used to even up a surface compresses unevenly under the roller and the result is a rough riding surface.

Wisconsin is making an experiment with a cement mortar, mixed one part of cement to two parts of good sharp sand for this purpose. The mortar is feathered out, and its cost is not prohibitive as compared to the cost of a bituminous binder. The tar and grease is removed from the old pavement, in order to insure a bond, and a wire mesh is used to strengthen the patch. Evidence that mortar will bond with a concrete slab can be obtained by noting where workmen have mixed concrete on a pavement and failed to clean it all off.

This mortar equalized is opened at cracks and joints, so that movement of individual slabs or sections of slabs will not shatter the thin coating. The top course is of a bituminous type, sufficiently thick to have a cushioning effect to prevent heavy loaded vehicles from fracturing the thin mortar coat. They are experimenting with the mortar equalizing only in a small way, but believe it merits consideration.

Experiences in Wisconsin.—A few old concrete pavements have been covered in Wisconsin as follows: A section, built in 1912, was frozen during construction. In 1914 a curb was placed on both sides and the surface was paved with vitrified brick. Cement grout filler was used. This section is in fair condition now.

A section was widened and resurfaced with reinforced concrete averaging 3½ in. thick in 1917. The oil and tar was removed from the old slab and the surface was thoroughly scrubbed, using water and stiff brooms. Neat cement was sprinkled over the damp surface before the new concrete was placed. The reinforcement was triangle mesh and the mix was 1:1.5:2.5. Joints were placed in the new surface directly over those in the old slab. This section is giving very good service.

A section of 18-ft. pavement, built in 1912, was widened to 24 ft. in 1916 and resurfaced with asphaltic concrete. Curbs were built integral with the widening of the base. A 1-in. binder course and a 2-in. top course cost $1.50 per square yard in place. Binder was used to even up the old surface. This job is rough and has not given particularly good service. The maintenance cost has been high.

A very rough section of concrete was given a brush coat of hot asphalt, followed by stone chips. A second application of hot asphalt, covered with torpedo sand, completed the work. While this covering did not entirely eliminate the bumps, it served as a cushion and made the pavement ride much better. This work was done in 1915. The only maintenance this section has had was a light seal coat in 1918. Results are as good as could be expected, considering the cost. This is evidence that an asphalt mat will adhere to a concrete surface.

In order to determine the tenacity with which a mat coat will cling to a smooth concrete pavement, about 2,000 lin. ft. of new 18-ft. concrete in good condition was treated with an application of ⅓ gal. of tar, on which gravel ranging from ¼ to 1½ in. was distributed with shovels. The gravel was too coarse and the work was very poorly done. However, this mat coat is still in place. It has crowded to the side slightly; nevertheless, the slabs are still completely covered. The average thickness is about ⅛ in. A surface treatment of 1/6 gal. of tar in 1922 is all the maintenance we have given it. This experiment proves to our satisfaction that a tar mat will adhere to smooth concrete.

A defective section of new concrete pavement was covered with asphaltic macadam in 1921. The holes in the old pavement were filled with concrete. When the concrete had set sufficiently, the surface received a paint coat of cold tar. Granite chips ranging in size from ¼ in. to ¾ in. were spread over the surface and raked down smooth. Tar heated to 250° was then poured on with pouring pots, care being used not to fill the voids entirely. One-half-inch stone chips, sufficient to fill the voids, were then applied and a seal coat poured. A dusting of fine stone chips completed the work. No roller was available, so rolling was omitted. A seal coat was applied in 1924. That is all the maintenance this section has required. It is in good condition at the present time.

A section of 16-ft. concrete pavement 4,000 ft. long, built in 1914, was widened to 20 ft. and resurfaced with 5 in. of concrete in 1924. The oil and tar was removed from the old surface and the slab was thoroughly scrubbed with brooms and water. Concrete was mixed 1:2:4 and 42-lb. welded mesh reinforcement was used to hold the material in place. Although the old pavement was jointed, no joints were placed in the new top. The result was a badly cracked surface; however, this piece rides well and is giving very good service.

An old 14-ft. concrete pavement, built in 1912, was widened to 20 ft. and covered with 7 in. of concrete in 1923. The old slabs were badly worn and nearly every slab was cracked longitudinally. One-half-inch square bar reinforcement was used, and a parting strip on the center line. They believe

it advisable to use parting strip where concrete is used as resurfacing. The flexibility of the slab split down the center allows the slab below to warp and heave to a certain degree without rupturing the surface. This work is in good condition and bids fair to be a lasting improvement.

A one-mile section of poorly constructed pavement, built in 1920, has been covered with a 2-in. top of amiesite this season. This surface has been in service only a short time and they are not prepared to make any statement relative to its durability as a covering. The experiments of the eastern states would indicate that it has considerable merit for resurfacing purposes. It is our opinion that the essential thing to do prior to laying amiesite is to even up the old surface before placing the binder course and try to place the work to a true profile, and this holds true of any of the bituminous types of surfacing.

Rock asphalt is being used by some of our cities as a covering for worn concrete. It is easy to lay and presents a nice surface.

Summary.—The riding quality of a rough concrete road can be materially improved at small cost by a thin mat of tar. This mat will also reduce the wear.

If an old concrete pavement is not strong enough to bear the traffic, its life can be materially lengthened by resurfacing with a bituminous top, or such a slab can be strengthened and made to serve for many years by resurfacing with concrete.

It is considerably cheaper to cover the old slab than it is to remove the old slab and replace entirely. It costs from 50 to 75 cents per square yard to remove old concrete, and when it is removed, the next thing is to find a place to put it. If left in place, it certainly serves to support the new slab.

If an old pavement has sufficient stability to withstand the traffic and an asphalt concrete is used to even it up, it is nearly as cheap to widen the base 2 ft. on each side and build the curb integral with the widening as it is to build vertical curbs alongside the old slab.

If bituminous tops are to be used on our rough concrete roads, some kind of an equalizer that can be used in the shallow depressions must be devised. This material must be of such a nature that it can be feathered out and it must be unyielding when in place.

Dump Wagons with Roller Bearings.—Western dump wagons having Timken bearings and alemite grease equipment are being used by Studer & Manion, Excelsior, Minn., in grading Wisconsin Trunk Highway No. 24 from Comstock to Turtle Lake.

Compacting Fills by Jetting

Experiences of Missouri State Highway Department Given in Paper Before American Road Builders Association

By THOMAS H. CUTLER
Engineer of Construction, Missouri State Highway Department.

Contractors and engineers have found it difficult to construct fills in horizontal layers and to thoroughly compact the fills so that they will be suitable for paving. In recent years, many experiments have been made with water jetting and large fills to hasten final settlement. I have used this method for many years in sandy soil, but doubted the efficiency of jetting fills composed of loam, clay, or rocky soil.

Results of Water Jetting.—On 26 miles of work for which the grading and paving contracts were let at the same time, it was decided to see what could be done by jetting the large fills. All fills 4 ft. and over, except one, on this section of road, were jetted; the fill which was not jetted was 8 ft. in height, and a failure occurred within 2 months after the pavement was laid on this particular fill. There was no sign of failure of the pavement due to settlement on any of the other fills that were jetted, even after a period of more than one year. There was, however, a slight settlement of one 5-ft. fill near a culvert. This fill was only 5 ft. deep for a short distance, and there was probably some negligence on the part of the jetting force. A number of 8-ft. fills and some 20-ft. fills have not settled during the last 2 years. At least, there is no noticeable defect in the concrete pavement that was laid soon after the jetting was completed.

Study in Missouri. — Water jetting has so generally proven satisfactory that the Missouri State Highway Department is now using this method extensively. The state highway department during this last summer made a very careful study of one project in order to secure complete and accurate data regarding settlement of fills that have been jetted, and to ascertain the best methods of jetting. To assist us in making this study, concrete posts were set into the ground to a depth of 3½ ft. at right-angles to the centerline, and about 5 ft. outside of the limits of the sideslopes. A ½-in. rod in the center of the concrete post provided means for accurately aligning all measurements and distances, and also served as bench-marks. These markers are permanent and were set deep enough so as not to be affected by frost and they can be used at any time to determine the settlement in the fill or the pavement on the fill. Cross-sections were accurately taken as soon as the fills were completed, and also after rains, before jetting was started. After the fills were jetted, notes were taken each day for a week, and then once a week until the pavement was poured.

Jetting Equipment. — The jetting equipment used was an inch pipe with the nozzle end drawn down to a ½-in. hole. The top was fitted with a T-valve, which kept the supply hose from kinking and also provided a means of spraying the road surface without delaying the jetting. Water was pumped as far as 4 miles through a 2-in. pipe with about 160 lbs. pressure at the pump, or 60 to 80 lbs. at the nozzle.

Settlement.—Very little effects were noted from rain which fell prior to the jetting, although there occurred three light rains, and one heavy rain during which 7.18 in. of water fell in 40 hours. The jetting was done on 5-ft. centers, the holes being first spudded about 3 ft. deep with a heavy crowbar. The average time to jet a hole in an 8-ft. clay fill was about 45 minutes.

After platting the cross-sections taken during a period of three weeks, the department found that very little settlement occurred later than 48 hours after jetting. Several of the fills which showed heavy settlements were checked for sideslope bulging. The settlement was found to be uniform from the shoulder to the toe of the slope; no bulging effect showed in any case. Data were kept and compared for every fill on 7 miles of work, with fills varying from 1 ft. to 14 ft. in height. Most of the fills on this job contained rock, sand, and clay; a test on the average sample showing 28 per cent rock, 21 per cent sand, and 51 per cent clay, by weight. The data secured showed 10 per cent settlement for every foot of fill over 4 ft. This percentage was also found on hard clay fills. The mealy clays and softer soils showed about 15 per cent shrinkage for fills over 4 ft. At the ends of bridges, culverts, and over deep holes where end dumping was necessary, the shrinkage was as high as 25 per cent, but usually about 20 per cent.

We also experimented by surface ponding the fills with water and digging holes at about the same spacing as was done with the jet. The pressure jetting seemed to be more satisfactory. Our cost figures on this work showed 4½ cents per cubic yard as the cost of the jetting, with labor at 50 cents per hour, gasoline and oil for the pump at $4 a day, and miscellaneous items at $1.40 a day. This amount does not include the cost or depreciation of the outfit used.

Texas Leads in Farm Owned Vehicles.—Corn belt States which for a number of years held the rural motor supremacy of the country are now rivaling the South for these laurels. Texas in 1926 headed the list of States having the largest number of cars on farms, while Iowa is in fourth place. The figures are 285,276 and 229,000 respectively.

Highway Widening

How Cuts Were Made With Leaning Wheel Grader

A mile of country road had to be widened in Ashland County, Ohio, last April, and the method used in doing the work proved interesting. In many places high banks full of roots and covered with underbrush, and in which even sizeable trees were growing, had to be cut to provide for the wider road, and this material used as fill to raise the grade and widen the fill elsewhere. This work, done by the county, was accomplished quickly and at about half the usual cost, by utilizing graders for work usually done with other equipment.

The underbrush and trees were first cut away and the stumps dynamited. After the ground had thus been cleared, the road was widened and graded by means of a Galion No. 12 leaning wheel E-Z lift grader with 12 ft. mouldboard, drawn by a Holt Caterpillar Sixty tractor. Where the dirt was to be moved for some distance it was handled by two McCormick-Deering tractors each pulling a Du-Pat wheel scraper.

Fig. 2—Large Banks Rapidly Cut as Shown Here.

The bank shown in the photographs, typical of the conditions found on the job, was approximately 10 ft. above the grade of the existing road at the point where the stakes were set, and these stakes called for the removal of as much as 8 ft. of this bank. As the bank was rather irregular, these figures denote the maximum bank that was found at this cut. A first cut removed the lower part of this bank. Next, the second cut made a further step upward, drawing down a large amount of earth, while a third cut moved this loosened dirt farther out and leveled it, making possible another cut into the bank. Then the process was repeated until the entire cut was completed.

A total length of bank of about ⅛ mile was thus cut down and a large extent moved in a little over two hours during one day. The grader seemed but little affected by the numerous small stumps and roots in the soil. These were simply cut and pulled out by the blade, and one man was kept busy gathering them and piling them out of the way.

After the banks had been cut down, the grader was used to move the dirt to the opposite side of the road to form the new shoulder required by the widening, and to carry part of the dirt to the lower parts of the road near by where the grade had to be raised, thus relieving the wheeled scrapers of quite a bit of work.

This interesting use of the grader is but an example of what may be done if the job is thought out on a logical basis irrespective of tradition.

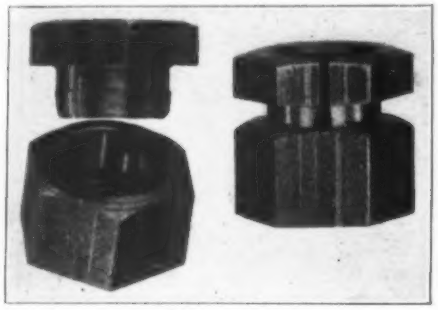
Fig. 1—Cutting Down the Bank with the Grader.

Plans Under Way for $25,000,000 of Road Work in New Jersey.—The State Highway Commission of New Jersey has plans under way for construction to cost over $25,000,000. The plans will form the basis for the construction program of 1928, provided the voters approve the $30,000,000 bond issue at the election in November. The routes proposed will not be taken over as part of the state highway system at this time. On the contrary, definite action will be contingent upon ratification of the bond issue. Should the issue fail, the construction program will necessarily be modified to come within available revenues.

The largest single outlay in the program is $4,000,000 for building 6.6 miles of the new Route 1 extension near Elizabeth. This would form a part of the approach to the Holland tunnel.

New Patent Lock Nut Introduced

A patented lock nut has been brought to this country that is said be unusually effective. The Larrad Nut, as it is called, has been used on some of the busiest railroad switches in the world. One one particular switch, say the manufacturers, the Larrad Nuts have remained tight ever since they have been on, which is now about seven months. No other form of nut has remained tight on the same switch longer than twenty days. This nut is being used by



Open and Closed views of the Larrad Nut.

the Keystone Driller Co. of Beaver Falls, Penn., on their model 4 road excavator, on rock crushers, stamp batteries and machinery of excessive vibration. The nut is made in all sizes from ¼ in. to 2 in. It is made in U. S. A. and S. A. E. standard, and can also be made in any thread desired. Also, larger sizes can be made to specifications when desired. Thomas H. Brown, 25 Beaver St., New York City, is the manufacturer.

California State Highway Widths.—The California Highway Commission is now making no pavement less than 20 ft. in width and in sections close to large centers widths of 30 and 40 ft. are used. Whittier boulevard in Los Angeles County, with a width of 56 ft. was built with county and special road fund cooperation, while Del Paso boulevard, in North Sacramento, recently completed, has a width of 76 ft. Property owners cooperated with the state in the building of this pavement.

Industrial Notes

The Chain Belt Co., Milwaukee, Wis., manufacturers of Rex chains, transmission, elevating, and conveying machinery announces that its Chicago office is now at Room 1515, 222 West Adams St., Chicago, Ill.

John R. Dean, formerly of New York City has taken over the management of the Service Department of Selden Truck Corporation, Rochester, N. Y. George Foos, who has been in the Service Department of the Selden Co. for many years, has been promoted to position of Assistant Service Manager.

W. F. Reece of Newburgh, N. Y., has been appointed District Manager by the Selden Truck Corporation for the Hudson River District of New York State. Mr. Reece was formerly associated with the Larrabee Company.

The Climax Engineering Co. announce the appointment of the James McGraw Co., Richmond, Va., as their sales agent in Richmond and vicinity. The James McGraw Company travel a number of salesmen throughout Virginia and North Carolina.

The Milburn Machinery Co., 141 North Front St., Columbus, O., have been appointed Rex Mixer and Paver distributors in that city by the Chain Belt Co., Milwaukee, Wisconsin.

At the annual meeting of **The Timken Roller Bearing Co.**, held at the main plant, Canton, O., on April 19, all the present officers were re-elected for another year. H. H. Timken is president; W. R. Timken, John G. Obermier, Marcus T. Lothrop, H. J. Porter and T. V. Buckwalter, are vice presidents; J. F. Strough is secretary and treasurer, and W. A. Brooks, is assistant secretary. Directors are H. H. Timken, W. R. Timken, Marcus T. Lothrop, John G. Obermier and J. F. Strough. Only routine business followed the election. The financial report of the Company was made public several weeks ago.

The George B. Curd Equipment Co. of 609 Reading Road, Cincinnati, O., has been appointed by the T. L. Smith Co. of Milwaukee as distributors of Smith Mixers and Pavers for the Cincinnati and Dayton territories.

Harnischfeger Corporation of Milwaukee, Wis., announce the removal of their Dallas, Tex., office from 401 Fidelity Union Building, into the Construction Industries Building. More adequate quarters were made necessary by the increased volume of crane and excavator business being handled in the Dallas territory.

E. R. Wyler, who has been connected with the Cleveland, O., sales branch of the Independent Pneumatic Tool Co., has been transferred to the sales department at the general offices of the company in Chicago. Mr. Wyler will make his headquarters in St. Paul, Minn.

Edward C. Dingman, Montreal dealer of the Climax Engineering Co., Clinton, Ia., has moved his office from the Keefer Building to 1120 Castle Building, 1410 Stanley St. Mr. Dingman is in a new building, more centrally located than his old location. Mr. Dingman handles the sale of Climax engines in Quebec and the eastern provinces of Canada.

The Climax Engineering Co., Clinton, Ia., has added two new men to the sales organization: H. P. McCullough will be located at Houston, Texas, with offices at 328 Chronicle Building, while E. H. Crippen will make his headquarters in Fort Worth, Texas, at 4023 W. 7th St. Mr. McCullough and Mr. Crippen are both experienced in the oil field practice. They have received training at the Climax engine factory at Clinton and have a very thorough understanding of the design and operation of Climax oil field units. The National Supply Companies are exclusive oil field distributors of Climax engines and the new members of the Climax sales force will work with them in the distribution of Climax products.

Frank T. Craven is now associated with Fox Bros. & Co., Incorporated, in charge of the Contractors' Equipment and Supply Department. The offices of the firm are at 126 LaFayette St., New York City.

D. R. Hoadley, secretary, director, and acting treasurer of the Novo Engine Co., Lansing, Mich., for the past 13 years, and formerly advertising manager of that concern, has resigned and is to enter upon a new line of business.

The T. L. Smith Co., of Milwaukee, has appointed the Bublitz Machinery Co., 2139 Washington St., Kansas City, Mo., as the distributors for Smith Pavers in Kansas and western Missouri. Payne G. West, 2937 East Grand Blvd., Detroit, Mich., has been appointed by the same company as distributor of Smith Mixers and Pavers for the Eastern Michigan territory.

New Trade Publications

The following trade publications of interest to highway officials, engineers and contractors have been issued recently. Copies of them can be obtained by addressing the firms mentioned:

Concrete Base Construction. — The American Vibrolithic Corporation, Insurance Exchange Building, Des Moines, Iowa, has issued a publication known as Engineering Bulletin Number 12, entitled "Interlocking Bituminous Pavements." This is a treatise on recent developments in concrete base construction, and was prepared by A. R. Hirst, formerly State Highway Engineer for the state of Wisconsin. Quotations from the recent Philadelphia Conference on Concrete Bases, reprinted from "Engineers and Engineering," occupy a prominent place in this publication. Several reports by Dow and Smith, consulting engineers and specialists on asphalt pavement work, are presented. Copies of this bulletin will be sent upon application to the above address.

Drainage Gates.—The California Corrugated Culvert Co., of West Berkeley, Calif., has just issued their 1927 handbook, entitled "Solutions for Drainage and Flood Control Problems." This handbook illustrates and explains the nature, use, and installation of Calco Automatic Drainage Gates and pipe culverts in various soil conditions and for various purposes. A circular tells about this book and illustrates several uses for the gates.

Graders.—The Galion Iron Works & Manufacturing Co., of Galion, O., in two bulletins just issued, describe their Galion Leaning Wheel E-Z Lift Graders, and their Fordson E-Z Lift Motor Grader. The leaning wheel graders have a number of interesting features in design and construction, these features being displayed in the bulletin. Various parts are illustrated, and views inside the factory are shown. An interesting road widening job done in Ashland County, Ohio, is also shown. The Fordson machine is described in a separate bulletin. This machine, containing some of the features found in the other models, utilizes a Fordson tractor for power. This tractor is located at the rear of the machine, and all controls are easily operated from the driver's seat.

The Koehring Co., Milwaukee, Wis., manufacturers of pavers, mixers, gasoline shovels, cranes, and draglines, has just issued a 40-page catalog describing its new No. 501 machine. This is a power shovel that may also be purchased as a crane or dragline if desired. As a shovel, three sizes of dippers may be had, depending upon the length of the dipper sticks and the kind of work for which the machine is to be used. The shortest stick is 13 ft. and takes a 1½ yard dipper, while the longest 19 ft. stick takes a 1 yard dipper. The boom length is 24 ft. Other interesting features are described.

Conveyors.—The Portable Machinery Co., of Passaic, N. J., has just issued a new catalog No. 127 describing their portable conveyors. This interesting publication illustrates many uses of the various types of conveyors, showing by actual photographs how many users have actually utilized the machines in handling a diversity of products under a variety of conditions. The types of conveyors manufactured by the concern are described in detail, and the growth of mechanical handling of materials is reviewed.

Pavers.—"One Year Ahead!" is the interesting title of a booklet just issued by the Foote Co., Inc., of Nunda, N. Y., describing the advanced features found in the latest model Multi-Foote of the 14E and 27E sizes. The Timken bearings that reduce lubrication problems, the double-cone drum, the non-clogging bucket, the power discharge, and other features are illustrated. Condensed specifications are given, and some prominent users are listed.

Power Shovels.—The Koehring Co., of Milwaukee, Wis., has issued an interesting folder entitled "Speed," describing their latest power shovels and illustrating the features that make it a fast digger. Prominently displayed is the feature of design that permits running the dipper above and beyond the top of the boom—a feature useful in deep excavations where the truck receives the excavated material at the top of the bank.

Central Mixing Plants.—The Blaw-Knox Co., Pittsburgh, Pa., has just issued a booklet describing the installation of their Batcherplants equipped with batcher for coarse aggregates and their Inundator for the sand. Not only does the booklet illustrate various methods of installation, but it contains an unusually clear explanation of the inundation method, shows the application of the equipment to work governed by a water-ratio strength specification, describes a small inundator that has been perfected for the wheelbarrow job, and contains other information of interest. All points are well illustrated.

Tarvia.—The Barrett Co., manufacturers of Tarvia, have just submitted an interesting and handy computor called the "Tarvia-Meter." This device consisting of a celluloid dish with rotating radial arm, shows the quantity of Tarvia needed per mile at various rates of application and widths of road. It also computes the distance in lineal feet covered by various tank capacities at specified quantities per square yard for 8 ft. and for 9 ft. strips.

Finishing Machines.—A. W. French & Co., 8440 Lowe Ave., Chicago, manufacturers of the Ord Road Finisher, in the second of their current series of folders, take up the reputed ability of the machine to handle even more concrete than can be supplied to it by a 27-E paver. Other qualities are touched on in the same broadside.

Pumps.—The Dean Hill Pump Co., of Anderson, Ind., in their recently issued Bulletin No. 403, describe and give the specifications of their ball bearing type, double suction centrifugal pumps, which are particularly designed for services requiring from 20 to 160 gallons of water per minute at heads ranging from 20 ft. to 175 ft., through 1 in. to 2½ in. hose or pipe line.